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GENERAL SCIENCE

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PREFACE

The aim of this book is to present a comprehensive, accurate, and pedagogically sound review of *General Science* as taught in the best American high schools.

The following outstanding features of this book recommend it to teachers and pupils:

I. It is **up-to-date.**—The content meets the very latest requirements for the subject as prescribed by the Board of Regents for New York State high schools and by the syllabi of the best high schools in the country.

II. The **outline form** has been used, as far as possible, to help the pupil obtain a proper perspective of the subject.

III. Wherever possible, the material has been presented in **chart form**—the clearest and the most impressive form for review purposes.

IV. The text is profusely illustrated with clear and well labeled **outline drawings.**

V. **Experiments** are briefly and clearly summarized in tabular form. Those of special importance have been designated as **key experiments.**

VI. **Questions** carefully selected from recent examination papers enable the pupil to test his knowledge of the immediately preceding material.

VII. **Complete recent examination papers,** set by the Board of Regents for New York State high schools as a

final test of proficiency, provide additional drill material, and familiarize the pupil with the type of question he will be expected to answer in the final examination.

The author wishes to express his appreciation to Dr. William Lemkin, Instructor in General Science, High School of Commerce, New York City, for his careful reading of the manuscript and proofs, and for his constructive criticisms and suggestions.

R. W. S.

New York,
June, 1929.

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GENERAL SCIENCE

CHAPTER I

INTRODUCTION

I. Science.—Science is a body of systematically arranged knowledge gathered from careful and purposeful observation.

II. General Science.—General science is the study of the scientific facts and laws which relate to our environment.

III. Divisions of General Science

A. *Astronomy*—the study of the heavenly bodies.

B. *Biology*—the study of living things, both plants and animals.

1. *Botany* is the study of plants.
2. *Zoology* is the study of animals.

C. *Chemistry*—the study of matter and its changes.

D. *Physics*—the study of energy and matter, and their relation to each other.

E. *Geology*—the study of the composition and structure of the earth's surface.

F. *Bacteriology*—the study of microscopic plants called bacteria.

IV. Environment.—Our environment is made up of the various materials and forces that surround us and make life possible. The necessary factors of our environment are

A. Air, water, food, soil, plants, and animals (*forms of matter*).

B. Heat, light, sound, and electricity (*forms of energy*).

V. Reasons for Studying General Science.--The study of General Science teaches us

A. To appreciate the wonder, harmony, and beauty of the world in which we live.

B. To seek for the truth, and not to depend upon the authority of books alone, or on hearsay.

C. To encourage our curiosity about Nature and her wonderful ways, and thus satisfy our spiritual longings.

D. How to utilize most effectively the factors of our environment. It teaches us

1. How to conquer many germ diseases.
2. How to take better care of our bodies.
3. How to improve our sources of food.
4. How to improve our homes and our home environment.
5. How to improve our methods of farming and gardening.
6. How to combat harmful plants and animals.
7. How to conserve our natural resources, such as forests and wild life.
8. How to tap and use the reservoirs of energy in nature.
9. How to improve our means of communication and travel.

VI. The Scientific Method.—The scientific method is the process of experimentation and observation by which new discoveries are made and new problems solved. It leads to the formulation of hypotheses, theories, and laws.

A. An *experiment* is an act performed to discover or test some scientific truth.

B. A *hypothesis* is an explanation of a natural phenomenon which is believed to be correct, but which has not been proved.

C. A *theory* is a hypothesis the probability of whose correctness has been strengthened by evidence derived from experiments.

D. A *law* (or *principle*) is a theory which has been proved to be correct.

VII. Important Factors in an Experiment.—Every experiment includes the following important factors:

A. Problem
B. Materials
C. Method
D. Observations
E. Conclusion
F. Application

VIII. Some Illustrative Experiments

KEY EXPERIMENT

1. *Problem.*—Which is heavier, a quart of milk or a quart of water?
2. *Materials.*—Platform balance; a one-quart milk bottle; a quantity of water; enough milk to fill the bottle.
3. *Method.*—Fill the bottle with water and weigh. Pour off the water, dry the bottle, fill it with milk, and weigh again.
4. *Observation.*—The bottle, when filled with milk, weighs more than when it is filled with water.
5. *Conclusion.*—A quart of milk is heavier than a quart of water. Hence any quantity of milk is heavier than an equal quantity of water.
6. *Application.*—Adulterated or watered milk may be detected by comparing its weight with the weight of an equal quantity of pure milk.

Another Experiment

1. *Problem.*—Does air occupy space?
2. *Materials.*—Tumbler; jar of water.
3. *Method.*—Invert the tumbler and push it down into the jar of water (Fig. 1A).
4. *Observation.*—The water rises only a short distance into the tumbler.
5. *Conclusion.*—The air in the tumbler prevents the water from entering freely. Air must therefore occupy space.
6. *Application.*—Compressed air is used to prevent water from entering a diving bell or *caisson.*

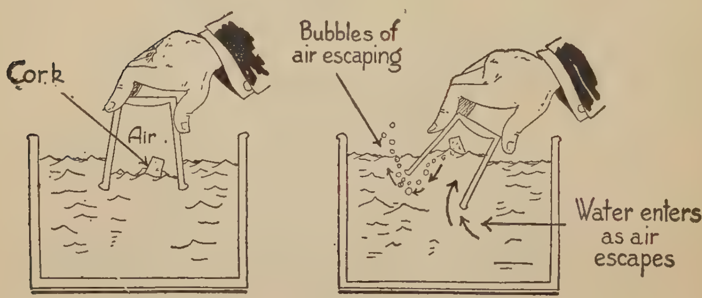


Fig. 1A Fig. 1B

Experiment to Prove that Air Occupies Space.

(The cork indicates the level of the water in the tumbler.)

IX. Control Experiments.—In most experiments, a *control* or *check* experiment is required to verify the accuracy of the conclusion. Thus, in the last experiment, the control experiment consists of tipping the inverted tumbler to one side while it is in the water (Fig. 1B). As the air escapes, the water enters the tumbler freely, thus verifying the conclusion that it was the air in the tumbler which prevented the free entrance of water.

QUESTIONS

1. *Define*: general science; chemistry; geology; biology; physics; law; theory.

2. Enumerate the necessary factors of your environment.

3. Give five good reasons for studying general science.

4. Give an illustration of the scientific method.

5. Discuss the importance of experiments in science.

6. (a) What six steps are involved in an experiment? (b) What additional step is often required after an experiment has been performed?

CHAPTER II

MATTER AND ITS COMPOSITION

I. States of Matter.—Matter is anything that occupies space and has weight. It may exist in three states:

A. As a *solid,* such as ice.

B. As a *liquid,* such as water.

C. As a *gas,* such as steam.

II. Kinds of Matter.—Matter is either *organic* or *inorganic.*

A. *Organic Matter.*—Organic matter is either alive or once formed a part of a living thing. It turns black when highly heated.

> **Example.**—Paper is organic matter because at one time it was part of a living tree.
>
> **Note.**—A few organic substances may be artificially produced.

B. *Inorganic Matter.*—Inorganic matter is not alive, and never was alive; that is, it was not produced by any living thing.

> **Examples.**—Glass, iron, water.

III. Elements.—An element is a substance which has not yet been decomposed into any other simpler substances.

> **Examples.**—Iron, lead, copper, carbon, sulphur, mercury, oxygen, nitrogen.

IV. Compounds.—A compound is a substance consisting of two or more elements chemically united. Every compound has a definite composition by weight, which may be represented by a formula.

Examples

COMPOUND	ELEMENTS PRESENT	FORMULA
Water	Hydrogen and oxygen	H_2O
Carbon dioxide	Carbon and oxygen	CO_2
Sodium chloride	Sodium and chlorine	$NaCl$
Quicklime	Calcium and oxygen	CaO

V. Mixtures.—A mixture is a material consisting of two or more substances not chemically united. It may be made up of elements or compounds or both. It has no definite composition and hence has no formula.

Examples.—Flour, milk, baking powder, granite, gasoline, air.

VI. What is the difference between a mixture and a compound? (Experiment)

METHOD	OBSERVATIONS AND CONCLUSIONS
Mix together a small quantity of iron filings and powdered sulphur. Pass a magnet through this material.	The magnet attracts the iron filings. The sulphur particles are left behind. *This material is therefore a mixture.*
Heat a mixture of iron filings and sulphur until it begins to glow. Allow the resulting substance to cool, and touch with a magnet.	The magnet does not attract the substance. *This substance is therefore a compound of iron and sulphur.*

Note.—Mixtures can be separated into their components by mechanical means. Compounds can be separated into their constituents only by chemical or electrical means.

VII. Atoms.—An atom is the smallest particle of an element that can take part in a chemical change. The atoms of every element consist of positive and negative charges of electricity. The positive charges are called **protons**; the negative charges are called **electrons.**

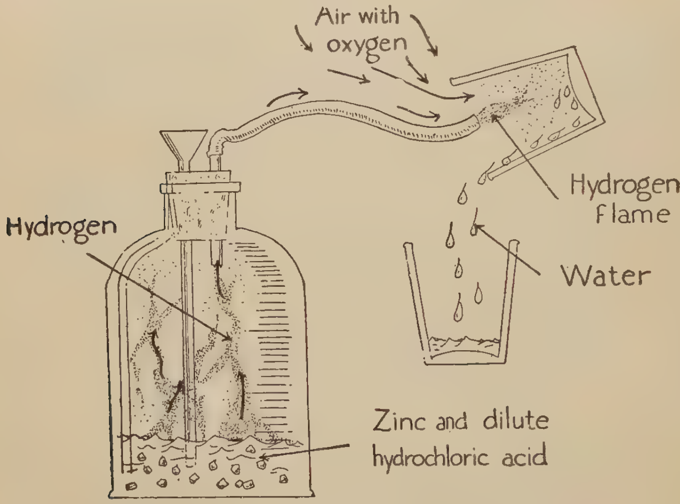


FIG. 2.—WATER IS FORMED WHEN HYDROGEN BURNS IN AIR. The hydrogen is prepared by adding dilute hydrochloric acid to zinc.

VIII. Molecules.—A molecule is the smallest particle of a substance that has the same properties as the substance itself. It may consist either of one element or of two or more elements.

Examples

A molecule of hydrogen (H_2) consists of two atoms of hydrogen.

A molecule of water (H_2O) consists of two atoms of hydrogen and one atom of oxygen.

A molecule of carbon dioxide (CO_2) consists of one atom of carbon and two atoms of oxygen.

IX. Properties of Important Elements

Element	Symbol	Properties
Carbon	C	Usually a black, insoluble solid. Burns readily, combining with oxygen to form carbon dioxide, an invisible gas.
Hydrogen	H	Colorless and odorless gas. Lightest substance known. Burns readily, combining with oxygen to form water (Fig. 2).
Oxygen	O	Colorless and odorless gas. Supports *combustion* (burning). Very active chemically. Combines with other elements, forming *oxides*.
Phosphorus	P	Waxy, light-yellow solid. Takes fire at ordinary temperatures.
Potassium	K	Soft, silvery metal. Decomposes water, liberating hydrogen.
Iodine	I	Steel-gray, crystalline solid. Dissolves in alcohol, forming *tincture of iodine*.
Nitrogen	N	Colorless and odorless gas. Very inert. Does not burn and does not support combustion.

Element	Symbol	Properties
Sulphur	S	Yellow solid, insoluble in water. Burns readily, combining with oxygen to form sulphur dioxide, a choking gas.
Calcium	Ca	Soft, silver-white metal.
Iron	Fe	Gray metal. Combines slowly with the oxygen of the air, forming rust (*iron oxide*).

Note.—There are about eighty-five elements. Those listed in the above table are the most common in our environment and in living things.

X. Physical Change.—A physical change is any change which does *not* alter the chemical composition of the substance.

Examples.—Sawing wood, melting a candle, freezing water, magnetizing iron, breaking glass.

XI. Chemical Change.—A chemical change is any change which alters the composition of the substance, thus forming one or more new substances.

Examples.—Burning of wood, rusting of iron, souring of milk, explosion of gunpowder, digestion of food.

XII. The Law of Conservation of Matter.—*Matter can neither be created nor destroyed.* When a candle burns, the materials of which it is composed are not destroyed; they are merely rearranged into other chemical combinations, such as water and carbon dioxide. The total weight of the new substances formed is equal to the combined weight of the candle and the oxygen with which the constituents of the candle combined in the process of burning.

QUESTIONS

1. *Define and illustrate*: element, compound, atom, mixture, molecule.

2. Give the important properties of each of the following elements: hydrogen, oxygen, nitrogen, carbon, iron.

3. Distinguish between a physical change and a chemical change.

4. Classify the following as physical or chemical changes: (a) cutting paper; (b) striking a match; (c) decaying of fruit; (d) evaporation of water; (e) burning of gas; (f) driving a nail; (g) heating copper in air; (h) tarnishing of silver; (i) explosion of dynamite; (j) the lighting of an incandescent electric lamp; (k) the change of cider into vinegar.

5. Classify the following substances as elements, compounds, or mixtures: water, air, soil, hydrogen, salt, kerosene, sugar, charcoal, mercury, granite.

6. State and illustrate the Law of Conservation of Matter.

CHAPTER III

AIR AND OXIDATION

I. Oxidation.—Oxidation is the chemical union of a substance with oxygen. Oxygen combines readily with many substances, liberating heat and usually light. The compound resulting from the union of a substance with oxygen is called an **oxide.**

Examples

Iron + Oxygen → Iron oxide (*little heat and no light*)

Carbon + Oxygen → Carbon dioxide (*heat and light*)

Hydrogen + Oxygen → Water (*heat and light*)

II. Rapid Oxidation.—Rapid oxidation is illustrated by the burning of a substance. It is always accompanied by light and intense heat.

III. Slow Oxidation.—Slow oxidation is any oxidation process that goes on slowly at ordinary temperatures. The total amount of heat liberated when a substance is slowly oxidized is the same as in rapid oxidation, but it is evolved so slowly that it is not noticeable.

Examples.—Rusting of iron, rotting of wood, oxidation of food in the bodies of living things.

IV. Is air necessary for combustion? (Key experiment)

PROCEDURE	OBSERVATIONS AND CONCLUSION
Place a lighted candle in each of two jars. Cover one jar with a cardboard.	The candle in the covered jar soon stops burning. The candle in the uncovered jar continues to burn. This proves that *a substance cannot burn in the absence of air.*

V. Composition of Air.—Air is a *mixture* composed approximately of

Oxygen, 21%	Rare gases, 1%
Nitrogen, 78%	Carbon dioxide, 0.04%

Note.—Air contains also variable amounts oi water vapor, dust, smoke, and bacteria.

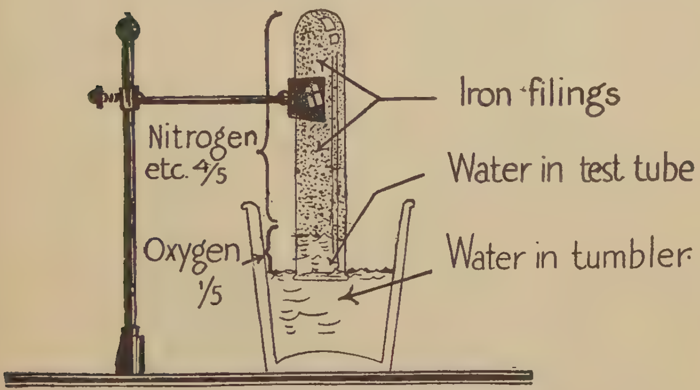


FIG. 3.—EXPERIMENT TO DETERMINE THE PERCENTAGE OF OXYGEN IN AIR.

VI. What percentage of the air is oxygen? (Key experiment)

PROCEDURE

Moisten the inside of a test tube with water and sprinkle some iron filings into it. Place the test tube, mouth downward, over water (Fig. 3). Let it stand over night.

OBSERVATIONS AND CONCLUSION

Reddened particles are seen where rusting has taken place, but many iron filings are still dark gray. Water is found to have ascended about one-fifth of the total height of the test tube. This shows that *one-fifth of the air in the test tube is oxygen.* This oxygen combined with some iron filings, forming rust. The remaining gas in the test tube is practically pure nitrogen.

VII. How to Prepare Oxygen. (Experiment)

Procedure

Set up the apparatus as shown in Fig. 4. Place in the test tube a small quantity of a mixture of potassium chlorate and manganese dioxide. Heat gently.

Observations and Conclusion

Bubbles of gas flow into the inverted jar. When a glowing splint is inserted into the jar, it bursts into flame. This shows that the gas is oxygen.

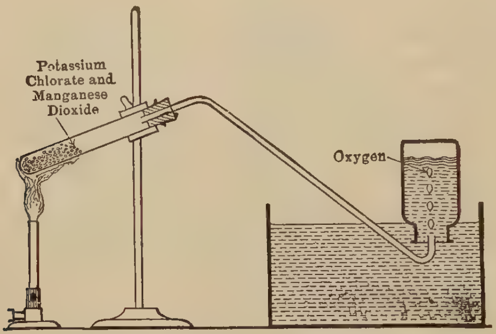


Fig. 4.—Preparation of Oxygen.

VIII. Uses of Fire.—Fire is used by man

A. To warm his home.

B. To cook his food.

C. To furnish power (steam engine, gasoline engine, etc.)

D. In industrial process, such as the manufacture of glass, the smelting of ores, etc.

IX. Factors Necessary for a Fire

A. A substance that will burn (*fuel*).

B. A continuous supply of air or oxygen.

C. A sufficiently high temperature.

Note.—The temperature at which a substance begins to burn is called its *kindling temperature.*

X. How to Determine the Kindling Temperatures of Various Substances. (Key demonstration)

PROCEDURE	OBSERVATIONS AND CONCLUSION
Place a tin plate on a ring stand. On the plate put a small piece of each of the following substances: phosphorus, sulphur, wood, paper. Heat the plate with a Bunsen burner.	The substances ignite in the following order: phosphorus, sulphur, paper, wood. Of the substances used, phosphorus has the lowest kindling temperature, and wood has the highest.

XI. Application of Kindling Temperature.—The ordinary match is a practical application of kindling temperature.

A. Friction ignites the phosphorus, which has a very low kindling temperature.

B. The burning phosphorus ignites the sulphur, which has a slightly higher kindling temperature.

C. The burning sulphur ignites the wood.

XII. Fuels.—A fuel is any material used to provide heat by burning. Only certain types of fuels are valuable for commercial purposes. A good commercial fuel should have the following characteristics:

A. A high calorific value; *i.e.*, it must give off considerable heat.

B. A high percentage of carbon and hydrogen.

C. It must not form poisonous fumes when it burns.

D. It must not leave too much ash after burning.

E. It must not be too bulky to store or to transport.

F. It must be available in large quantities, at a reasonable cost.

Note.—Wood, coal, gas, and gasoline meet all the above requirements; hence their wide use as commercial fuels.

XIII. What compounds are formed when common fuels are burned? (Experiment)

PROCEDURE	OBSERVATIONS AND CONCLUSION
Light a candle. Pour some cold water in a beaker and dry the outside surface thoroughly. Hold the beaker a few inches above the candle flame.	Drops of *water* collect on the outside surface of the beaker. The water resulted from the union of the hydrogen of the candle with the oxygen of the air.
Place a candle in an upright position in a tumbler and light it. After about a minute, remove the candle, pour a little lime water into the tumbler, and shake.	The lime water becomes milky in color, indicating the presence of *carbon dioxide.* This gas resulted from the union of the carbon of the candle with the oxygen of the air.

XIV. Some Common Fuels and Their Origin

FUEL	ORIGIN
Wood	Forests.
Coal	The partial decomposition of vegetable matter under ground by heat and pressure.
Coke	Made by heating soft coal in retorts from which the air has been removed.
Charcoal	Made by heating wood in the absence of air.
Petroleum	Probably formed by the decomposition of animal matter under ground.
Natural gas	Found with crude petroleum.
Coal gas	Made by heating soft coal in retorts from which the air has been removed.
Gasoline	Obtained by heating petroleum in stills.

XV. Fire Dangers and Losses

A. *Common Causes of Accidental Fires*

1. The careless handling of burning cigarettes, cigars, and matches.
2. Defective stoves, furnaces, chimneys, and flues.
3. *Spontaneous combustion*—active burning resulting from the accumulation of heat due to slow oxidation.

   Examples.—Fires starting in heaps of oily rags, in large quantities of soft coal dust, or in hay which has been put into a barn before being dried.

B. *Forest Fires.*—Every year forest fires destroy in the United States an area equivalent to a ten-mile strip, reaching from New York to Denver. These fires are usually caused by

1. Smoldering camp fires.
2. Sparks from passing locomotives.
3. Lightning.

C. *Reducing Fire Hazards.*—The number of destructive fires can be reduced by

1. Using fire-proof materials in building construction.
2. Providing adequate fire exits in buildings.
3. Taking care in the disposal of burning matches, cigarettes, etc.
4. Having fire drills at frequent intervals.
5. Extinguishing camp fires before leaving the camp site.

D. *First Aid to Fire Victims*

1. Wrap the person whose clothing has caught fire in a blanket, rug, or overcoat. The supply of air is thus cut off, and the fire is smothered.

2. Apply linseed oil and lime water or a paste made of baking soda and water to the injured part.

XVI. Construction, Principle, and Use of a Fire Extinguisher. (Experiment)

PROCEDURE

1. Fit a wide-mouthed bottle with a one-hole rubber stopper (Fig. 5).
2. Fill the bottle with a solution of bicarbonate of soda to about three-fourths of its height.
3. Suspend from the stopper a small vial containing sulphuric acid.
4. Insert a short glass tube through the hole in the stopper.
5. Invert the bottle, and direct the resulting stream from the tube on some burning paper in a basin.

OBSERVATIONS AND CONCLUSION

The sulphuric acid reacts with the solution of bicarbonate of soda, forming carbon dioxide so rapidly that the contents of the bottle are forced out through the glass tube and the fire is extinguished. The fire is extinguished because

1. The water cools the burning paper below its kindling temperature.
2. The mixture of water vapor and carbon dioxide acts like a blanket, thus excluding air from the burning paper.

XVII. Rusting.—Iron and steel objects, when exposed to air and moisture, undergo slow oxidation or rusting. Rusting may be prevented by

A. Covering the object with grease or oil.
B. Nickel-plating, galvanizing, or tinning.
C. Painting or enameling.

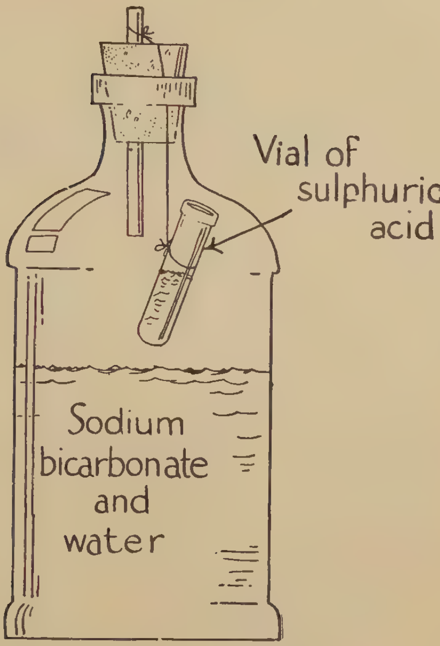


FIG. 5.—A MODEL FIRE EXTINGUISHER.

QUESTIONS

1. (a) What three conditions are necessary for making a fire? (b) Describe experiments to illustrate the necessity of each of these conditions.

2. Explain how the burning of a match illustrates the meaning of *kindling temperature.*

3. (a) What oxides are formed when a fuel burns? (b) What elements must be present in the fuel? (c) What forms of energy are evolved?

4. State five ways of minimizing fire hazards.

5. Describe three methods of extinguishing a fire.

6. When iron rusts, does its weight increase or decrease? Explain.

7. What chemical elements are present in a candle? Give reasons for your answer.

8. Describe the first aid procedure in case of (a) clothing which has caught fire; (b) scalds or burns.

9. Give three methods of preventing the rusting of a metal.

10. Describe the construction and operation of a fire extinguisher.

CHAPTER IV

WEATHER AND CLIMATE

I. Weather.—Weather is the general condition of the atmosphere at any given time and place.

II. Factors Determining Weather.—Weather is determined by the following atmospheric conditions:

A. Temperature. C. Humidity.
B. Pressure. D. Winds.

Note.—The term *humidity* refers to the amount of water vapor in the air. Winds are caused by the movements of air.

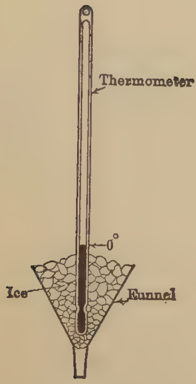


FIG. 6.—DETERMINATION OF THE FREEZING POINT.

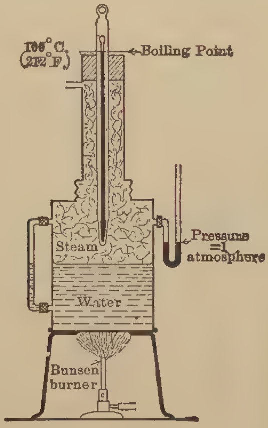


FIG. 7.—DETERMINATION OF THE BOILING POINT.

III. Measurement of Temperature.—Temperature is measured by means of a thermometer (*thermos* = heat + *meter* = measure).

IV. The Fixed Points of a Thermometer.—The freezing point and boiling point of pure water under normal atmospheric pressure are the so-called *fixed points* of a thermometer.

A. *The Freezing Point.*—The freezing point is determined by placing the bulb of the thermometer in finely crushed melting ice (Fig. 6). The place at which the mercury column becomes stationary is the freezing point.

B. *The Boiling Point.*—The boiling point is determined by enveloping the bulb of the thermometer with steam from boiling water at normal atmospheric pressure (Fig. 7). The place at which the mercury column becomes stationary is the boiling point.

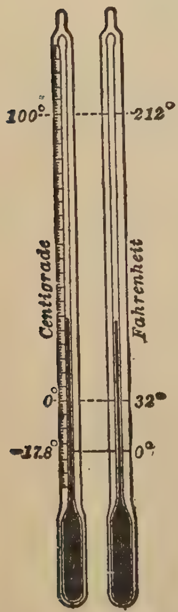


Fig. 8.—Centigrade and Fahrenheit Thermometers.

V. Thermometric Scales (Fig. 8)

A. *The Centigrade Scale*

1. The freezing point is marked **0°** and the boiling point **100°**.
2. The intervening space is divided into 100 equal parts, or degrees.

B. *The Fahrenheit Scale*

1. The freezing point is marked **32°** and the boiling point **212°**.
2. The intervening space is divided into 180 equal parts, or degrees.

VI. Irregularities in Heat Distribution.—The actual boundaries of the climatic zones of the earth are irregular and varied. This is due to

A. *The Seasons.*—Seasonal changes in temperature are due to the inclination of the earth's axis and the revolution of the earth around the sun.

B. *Variations in Altitude.*—Highlands are cooler than neighboring lowlands.

C. *Bodies of Water.*—Oceanic islands and seacoasts have a more equable temperature than interiors.

D. *Prevailing Winds.*—The prevailing west winds blowing over western United States and western Europe moderate the cold of winter and the heat of summer.

E. *Ocean Currents.*—For example, the cold Labrador Current gives New England a severe winter and a cool summer.

F. *Topography.*—For example, the high Alps shut out the cold north winds and give the Mediterranean region a mild climate.

VII. What is the effect of bodies of water on the temperature of the air? (Experiment)

Procedure	Observations and Conclusion
1. Heat some soil in a beaker. 2. In another beaker heat an equal volume of water to the same temperature. 3. Set both beakers aside, and note the temperature of each at frequent intervals.	It requires more time to heat the water to the same temperature as the soil. The soil cools much more rapidly than the water. Hence bodies of water warm, and also cool, more slowly than land. This accounts for the fact that air over land is warmer during the day and in summer, and cooler during the night and in winter, than the air over water.

VIII. Measurement of Air Pressure.—Air pressure is measured by means of a barometer (*baros* = pressure + *meter* = measure).

IX. How to Make a Mercury Barometer. (Key demonstration)

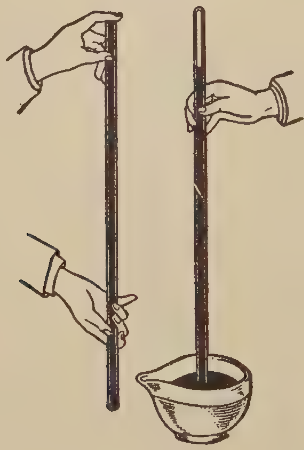


FIG. 9.—MAKING A MERCURY BAROMETER.

PROCEDURE	OBSERVATIONS AND CONCLUSION
1. Take a glass tube about 34 in. long and closed at one end, and fill it with mercury (Fig. 9).	The column of mercury in the tube drops until its upper surface is about 30 in. above the surface of the mercury in the bowl.
2. Close the open end with a finger and place this end below the surface of mercury in a bowl.	This column of mercury is supported by a similar column of air, as high as the limits of the atmosphere, which presses on the surface of the mercury in the bowl.
3. Withdraw the finger.	

Note.—At sea level, the average height of the mercury column is 30 in. When the air pressure increases, the mercury column rises; when it decreases, the mercury column falls.

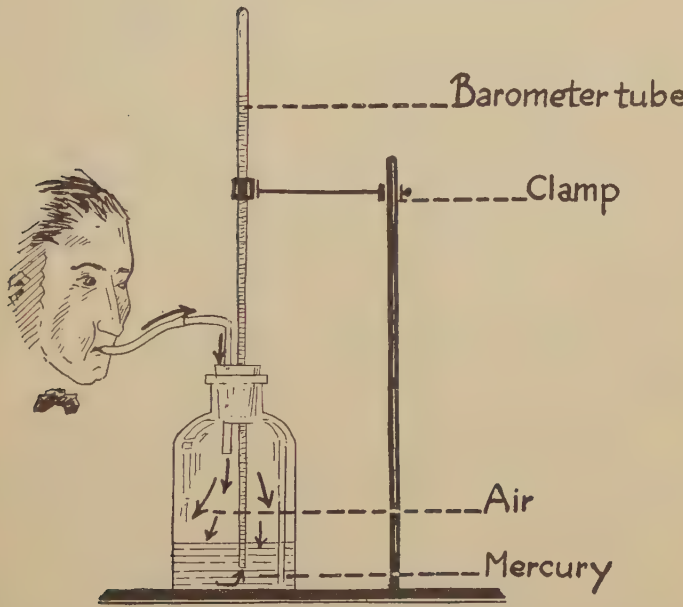


FIG. 11.

Explain what happens to the column of mercury in the barometer tube.

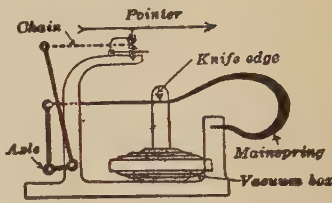
X. The Aneroid Barometer.—The aneroid barometer (Fig. 10) contains no liquid and is therefore much more convenient to carry than a mercury barometer. It consists essentially of the following parts:

A. A hollow cylindrical metal box from which the air has been partially excluded. The box is provided with a flexible metal cover.

B. A chain and lever connection from the center of the cover to the pointer.

C. A hair-spring to take up the slack in the chain.

D. A dial calibrated by comparison with a mercury barometer.



Courtesy Macmillan Co.

FIG. 10.—THE ANEROID BAROMETER.

An increase in the air pressure on the cover of the box causes the pointer to read higher. A decrease in the air pressure permits the elastic cover to spring back in proportion to the decrease, and the pointer reads lower.

XI. Humidity.—The amount of water vapor in the air at any given time is known as its *humidity.*

A. *Absolute Humidity.*—The absolute humidity of the air is the amount of water vapor in a unit volume of air at a given temperature (*e.g.,* 4 grains per cu. ft.).

B. *Possible Humidity.*—The possible humidity of the air is the amount of water vapor that a unit volume of air *could* hold at a given temperature. The higher the temperature of the air, the more water vapor it is capable of holding.

C. *Relative Humidity.*—Relative humidity is the ratio of the amount of water vapor which the air holds and the amount it *could* hold at the given temperature if it were saturated. Thus, a relative humidity of 60% means that a given volume of air holds 60% as much water vapor as it *could* hold at the observed temperature.

XII. How to Measure Relative Humidity by Means of a Hygrometer. (Key demonstration)

PROCEDURE

1. Wrap a small piece of muslin around the bulb of a thermometer and let one end of the muslin dip in a dish of water.
2. Place another thermometer nearby.
3. Fan the bulb of the first thermometer for a few minutes.
4. Compare the readings of both thermometers.

OBSERVATION AND CONCLUSION

The evaporation of water from the wet bulb lowers the reading of that thermometer.

A large difference in temperature indicates rapid evaporation and therefore low humidity. A small difference in temperature indicates slow evaporation, and therefore high humidity.

Note.—If there is no difference in the readings of both thermometers, the relative humidity is 100%.

XIII. How to Use the Table for Finding Relative Humidity.—Suppose that the dry-bulb thermometer registers 68° and the wet-bulb thermometer, 60°. The difference between the two readings is 8°. In the table on page 28, look down the column headed by the figure 8 until you reach the number on the same line as the reading of the dry-bulb thermometer. In this case, the number is 63, which is the relative humidity; *i.e.*, the air is 63% saturated, or is holding 63% of the amount of water vapor it could hold at the temperature indicated by the dry-bulb thermometer.

XIV. Precipitation.—Precipitation is the process by which the water vapor in the air is condensed in the form of either a liquid (*rain, dew*) or a solid (*snow, hail, frost*). Condensation of water vapor takes place when the temperature of the air drops sufficiently.

TABLE FOR FINDING RELATIVE HUMIDITY (PERCENTAGES)

Dry Therm. (Air Temp.)	Difference Between Dry- and Wet-bulb Thermometers														
	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18
50	93	87	81	74	68	62	56	50	44	39	33	28	17	7	
52	94	88	81	75	69	63	58	52	46	41	36	30	20	10	0
54	94	88	82	76	70	65	59	54	48	43	38	33	23	14	5
56	94	88	82	77	71	66	61	55	50	45	40	35	26	17	8
58	94	89	83	77	72	67	62	57	52	47	42	38	28	20	11
60	94	89	84	78	73	68	63	58	53	49	44	40	31	22	14
62	94	89	84	79	74	69	64	60	55	50	46	41	33	25	17
64	95	90	85	79	75	70	66	61	56	52	48	43	35	27	20
66	95	90	85	80	76	71	66	62	58	53	49	45	37	29	22
68	95	90	85	81	76	72	67	63	59	55	51	47	39	31	24
70	95	90	86	81	77	72	68	64	60	56	52	48	40	33	26
72	95	91	86	82	78	73	69	65	61	57	53	49	42	35	28
74	95	91	86	82	78	74	70	66	62	58	54	51	44	37	30
76	96	91	87	83	78	74	70	67	63	59	55	52	45	38	32
78	96	91	87	83	79	75	71	67	64	60	57	53	46	40	34
80	96	91	87	83	79	76	72	68	64	61	57	54	47	41	35
84	96	92	88	84	80	77	73	70	66	63	59	56	50	44	38
88	96	92	88	85	81	78	74	71	67	64	61	58	52	46	41
92	96	92	89	85	82	78	75	72	69	65	62	59	54	48	43
96	96	93	89	86	82	79	76	73	70	67	64	61	55	50	45
100	96	93	90	86	83	80	77	74	71	68	65	62	57	52	47

XV. Varying Results of Condensation

A. *Rain* results when water vapor condenses at a temperature above 32° F.

B. *Hail* results when rain passes from a high altitude through an area having a very low temperature.

C. *Snow* results when water vapor condenses at a temperature below 32° F.

D. *Dew* results when water vapor condenses on cold objects on the surface of the earth.

E. *Frost* results when water vapor condenses on objects whose temperature is below the freezing point.

FIG. 12.—HOW HAILSTONES ARE FORMED.

F. *Fog* or *mist* results when condensation of water vapor takes place in masses of air near the earth's surface.

G. *Clouds* result when condensation of water vapor occurs above the earth's surface, forming floating masses of mist.

XVI. How to Determine the Dew Point. (Demonstration)

Procedure	Observation and Conclusion
Place some cracked ice and water in a brightly polished metal cup. Stir the water with a thermometer until mist appears on the outer surface of the cup. Note the temperature of the water just as the mist appears.	The mist on the cup is condensed water vapor. The temperature noted at the instant the mist appeared is the dew point.

Note.—The dew point varies with the amount of water vapor in the air at the time of observation. For example, if the air is nearly saturated (high relative humidity), only a small drop in temperature is required to reach the dew point.

XVII. Factors Influencing the Amount of Rainfall

A. *The Tropics.*—Heated air carrying water vapor to higher altitudes is cooled and the vapor condenses. This results in a humid climate.

B. *Mountain Barriers*

1. The side of a mountain range facing the wind which blows from the ocean has much rain, because the vapor-laden air is forced to higher and cooler regions and is thereby cooled to the condensation point.

   Example.—The western slope of the Pacific Coast Range.

2. The side of a mountain range opposite to that which the wind strikes is very dry, because the moving air has lost most of its moisture on the other side of the mountain.

   Example.—The Great American Desert just east of the Pacific Coast Range.

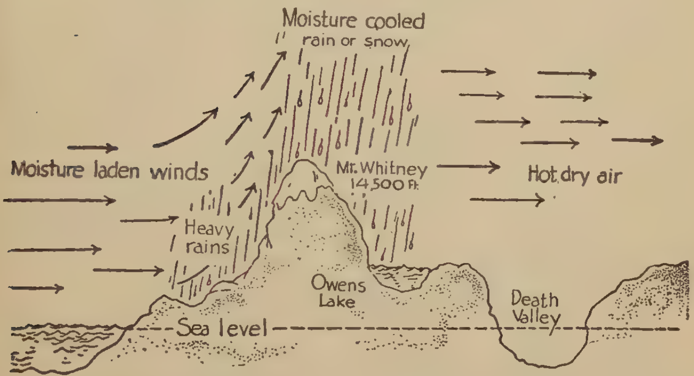


FIG. 13.—HOW MOUNTAIN BARRIERS MAY FORM DESERTS.

XVIII. Winds.—Winds are air currents.

A. When there is a difference in the temperature of two areas, the air over the warmer area expands and becomes lighter. The air from the cooler area, being heavier, flows along the surface to the warmer area, thus pushing the lighter air up (Fig. 14).

B. The flow is always from regions of high air pressure to regions of lower air pressure.

XIX. Land and Sea Breezes

A. *Land breezes* occur because the water of the ocean cools less rapidly than the land during the night. The heavier air over the land therefore flows seaward during the forenoon.

B. During the day these conditions are reversed, the land heating more rapidly than the water. The

cooler and heavier air therefore flows from the sea over the land during the afternoon and evening. These movements of air are called *sea breezes.*

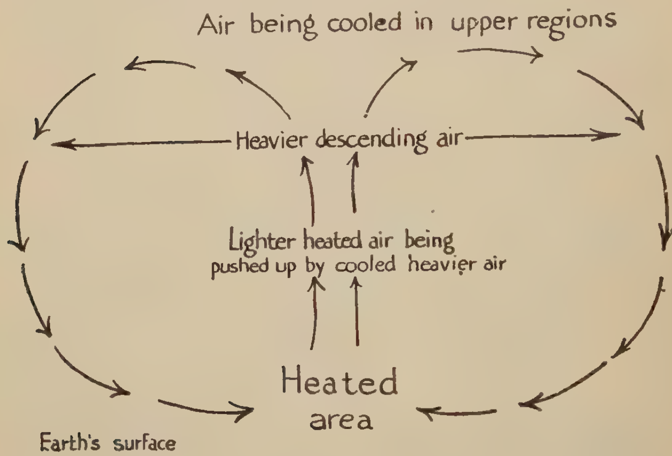


FIG. 14.—CONVECTION CURRENTS OF AIR OVER A HEATED AREA.

XX. The Interaction of Weather Factors.—The various factors determining weather interact with the following results:

A. *Thunderstorms.*—Thunderstorms are local disturbances caused by a sudden rise of highly heated air. The resulting extremely rapid condensation of water vapor generates frictional electricity. A lightning flash results when the electrical pressure between the earth and the clouds becomes sufficiently great. The thunder is caused by the sudden contraction of the air which was heated and rapidly expanded by the lightning flash.

B. *Tornadoes.* — Tornadoes are violently whirling windstorms, traveling a short distance over a very narrow path. When occurring on the ocean they are called *hurricanes.*

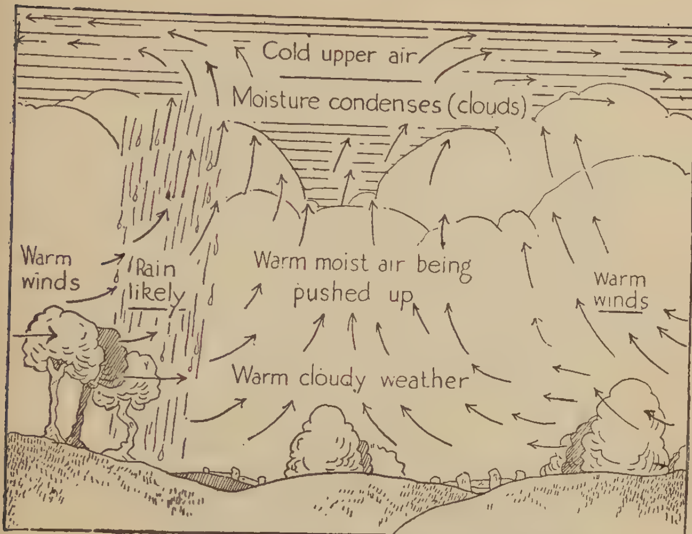


FIG. 15.—LOW PRESSURE AREA OR CYCLONE.

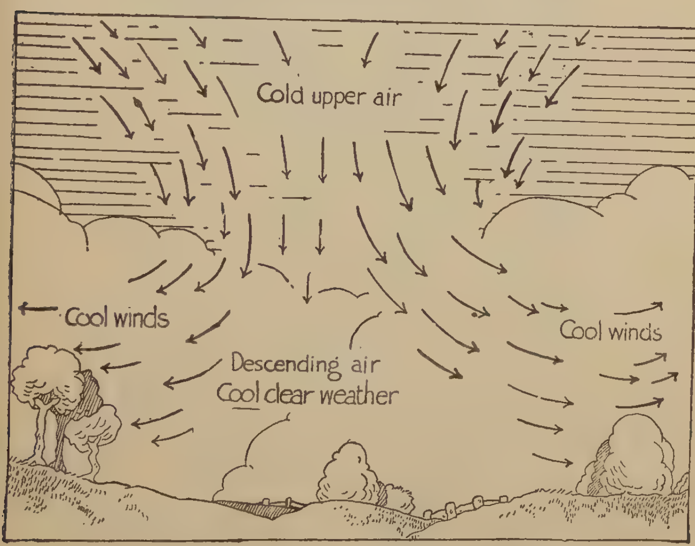
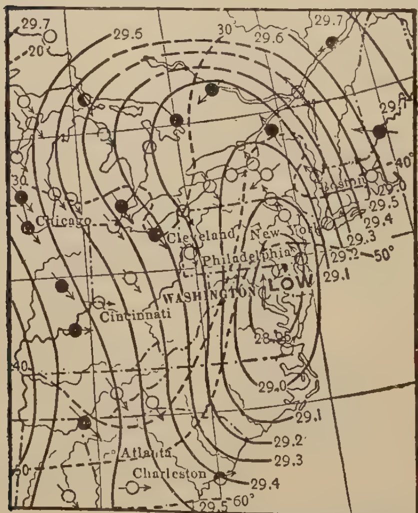


FIG. 16.—HIGH PRESSURE AREA OR ANTI-CYCLONE.

C. *Cyclones or Lows.*—These are areas of low barometric pressure having cloudy and rainy weather. The air about a *low* moves spirally *inward* toward the center of the area. (Fig. 15.)

D. *Anticyclones or Highs.*—These are areas of high barometric pressure having fair and cool weather. The air about a *high* moves spirally *outward* from the center. (Fig. 16.)

> **Note.**—In general, *highs* and *lows* follow each other across the United States in an easterly or northeasterly direction at a speed of about 700 miles a day.



Courtesy, The Macmillan Co.

FIG. 17.—PORTION OF A U. S. WEATHER MAP.

XXI. Weather Forecasting.—The Weather Bureau at Washington is able to predict the weather for any given place.

A. Observations of the weather are made daily at many stations in all parts of the country. These observations are telegraphed to Washington.

B. The temperature, air pressure, and amount of rainfall are plotted on a large map (Fig. 17) and are studied by the official forecaster.

C. The locations of *highs* and *lows* are noted, and their general direction and speed are estimated.

D. Predictions are then made for the next 36 hours, and broadcast to all parts of the country.

XXII. The Barometer and Weather Changes

A. *A falling barometer indicates the approach of a low pressure area.* The central, southern, and eastern portions of the low pressure area usually have precipitation (*rain* or *snow*).

B. *A rising barometer indicates the approach of a high pressure area.* A high pressure area always brings cool, clear, dry weather.

C. *An unchanging high barometer indicates clear, settled weather.*

XXIII. Value of Weather Forecasts.—Weather forecasts are of great value to many classes of people.

A. Farmers and fruit growers receive advance warning of hot and cold waves, rains, etc., and thus know when to take special measures to prevent damage to crops.

B. Shippers of perishable goods are enabled to protect their products against unfavorable weather conditions during shipment.

C. Navigators receive warnings of storms.

D. Aviators obtain information helpful to them in determining the best routes and time of flying.

QUESTIONS

1. (a) Describe a mercury thermometer. (b) What two kinds of thermometers are in common use? (c) How do their fixed points differ?

2. On a clear day, a sidewalk feels warmer than the air above it. Explain.

3. Compare land and water with respect to their capacity for (a) absorbing heat from the sun; (b) giving off heat previously absorbed from the sun.

4. Mention some specific localities where the climate depends upon the facts suggested in Question 3.

5. (a) Mention five factors upon which the temperature of a locality depends. (b) Give an example of a locality where each of these factors is important.

6. (a) Describe the construction and reading of a mercury barometer. (b) In what respect does an aneroid barometer differ from a mercury barometer?

7. Explain the causes of (a) land and sea breezes; (b) mountain and valley breezes.

8. (a) What causes atmospheric pressure? (b) Upon what two main factors does atmospheric pressure depend?

9. *Define:* absolute humidity; possible humidity; relative humidity; dew point; condensation; saturation.

10. (a) Mention the four chief factors that determine the rainfall of a place. (b) Give an example of an effect of each of these factors.

11. Explain how a mountain barrier affects the rainfall of a region. Give an example.

12. (a) Mention the five main factors that control the climate of a region. (b) Describe the effect of each factor.

13. State one effect of each of the following on climate: (a) altitude; (b) latitude; (c) prevailing winds; (d) neighboring bodies of water; (e) slope of the land. Give reasons.

14. With a cyclone center at St. Louis on a given day, forecast the weather for the next day in (a) Kansas City; (b) Pittsburgh.

15. (a) What observations are made by the observers employed by the U. S. Weather Bureau? (b) How is the information collected each day? (c) How is it made available to the general public?

CHAPTER V

WATER IN THE HOME AND THE COMMUNITY

I. Characteristics of Water

A. It occurs as a solid (*ice*), a liquid (*water*), or a vapor (*steam*).

B. It boils at 212° F. (100° C.) and freezes at 32° F. (0° C.).

C. It is a *universal solvent*. All substances are soluble to some extent in water.

D. Its taste is due to dissolved mineral matter and air. Absolutely pure water is tasteless.

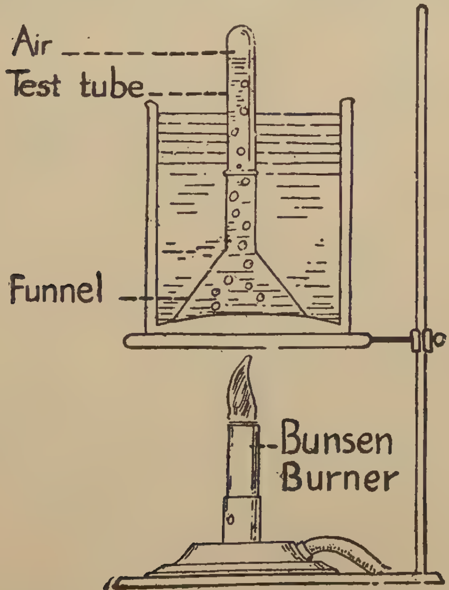


FIG. 18.—EXPERIMENT TO SHOW THAT WATER CONTAINS AIR IN SOLUTION.

II. Does water contain air? (Key experiment)

PROCEDURE

Invert a small funnel in a beaker containing water. Fill a test tube with water and invert it over the stem of the funnel ~~(Fig. 18)~~. Heat the water gently.

OBSERVATION AND CONCLUSION

Air collects in the top of the inverted test tube. This proves that *water contains dissolved air.*

Note.—Fish and other forms of aquatic life use the dissolved air for respiration.

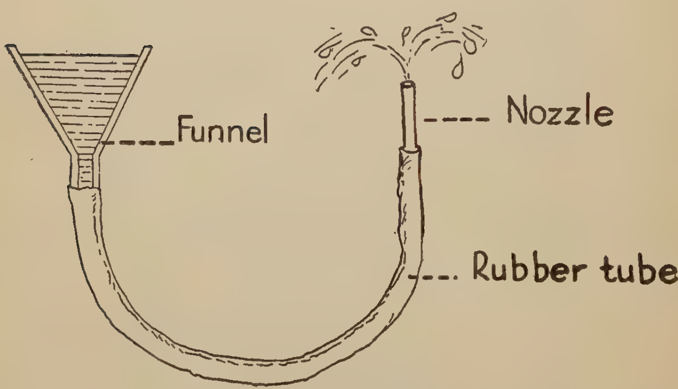


FIG. 19.—EXPERIMENT TO SHOW THAT WATER SEEKS ITS LEVEL.

III. Methods of Obtaining Water

A. The *gravity system* is used by communities located near hills or mountains, where a reservoir can be constructed at a higher elevation than the place supplied. Los Angeles uses this system.

B. The *pumping system* is used by communities located at a higher elevation than the source of water. Chicago uses this system.

C. A *combination* of the gravity and pumping systems is used where the force of gravity is insufficient to drive water to the top of very tall buildings. New York City uses the combined systems.

D. The *lift pump* is used in rural communities to obtain water from wells, springs, and cisterns.

IV. How does gravity furnish us with water? (Key experiment)

PROCEDURE

Attach one end of a piece of rubber tubing to the stem of a funnel, and the other end to a glass tube (~~Fig. 19~~). Fill the funnel almost full of water. Raise or lower the rubber tubing until the water is visible in the glass tube.

OBSERVATION AND CONCLUSION

The water rises in the glass tube to the same level as in the funnel, showing that gravity causes water *to seek its own level.* Any point below the level of a reservoir will receive water by the force of gravity.

V. The Lift Pump (~~Fig. 20~~).—The lift pump is used to raise water from a well, and whenever pumping on a small scale is required.

FIRST UPSTROKE

The pressure of the air in *A* is reduced.

Valve V_1 is therefore opened and valve V_2 is closed.

The pressure of the air on the surface of the water in *R* forces some of the water into the cylinder.

DOWNSTROKE

The weight of the water in the cylinder closes valve V_1.

The pressure of the piston on the water in the cylinder forces open valve V_2.

Water from *A* is forced into *B* above the piston.

SECOND UPSTROKE

The water above the piston is lifted and flows out of the spout *N*. The process is then repeated.

VI. The Force Pump (Fig. 21).—The force pump is used whenever pumping on a large scale is required, and whenever a continuous flow of water is desired, as in fire-engines and in city water supply systems.

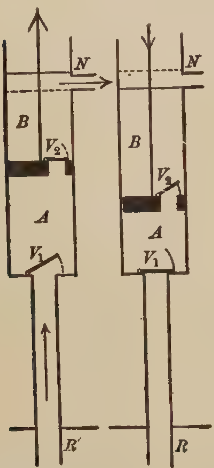


Fig. 20.—The Lift Pump.

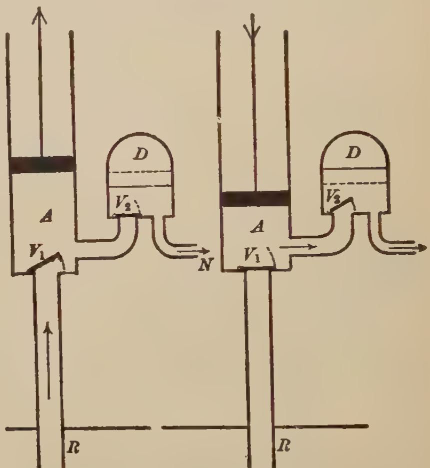


Fig. 21.—The Force Pump.

Upstroke

The air pressure in A is reduced.

Valve V_1 is therefore opened and valve V_2 is closed.

The atmospheric pressure on the surface of the water in R forces some of the water into the cylinder.

Downstroke

The air in A is compressed.

Valve V_1 is therefore closed and valve V_2 is opened.

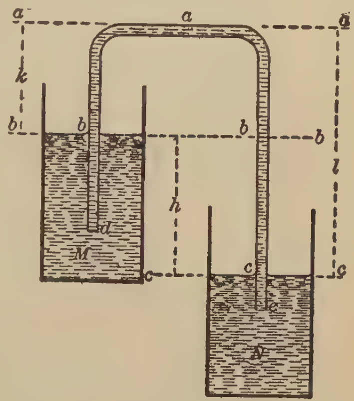
The water is forced by the moving piston into airdome D, some of it flowing out through the outlet pipe N.

Note.—When water enters the airdome D, the air in it is compressed. During the following upstroke, the air in the dome expands and forces the water which it contains out through N. A continuous stream of water thus results.

VII. The Siphon.—A siphon is a bent tube of glass, rubber, or metal, having arms of unequal length (Fig. 22). It serves to transfer a liquid over an elevation from one vessel to another at a lower level.

A. *Operation*

1. The siphon is filled with water.
2. Its openings are closed with the fingers, and the shorter arm is introduced into the liquid at the higher level.
3. When the fingers are removed, the liquid continues to flow as long as the end of the shorter arm of the siphon is covered by it and the levels of the liquid are unequal.



Courtesy, D. C. Heath & Co.
FIG. 22.—THE SIPHON.

> **Note.**—The liquid flows through the siphon because the column of water in *ac* is heavier than the column of water in *ab*.

B. *Uses*

1. In handling corrosive liquids.
2. To remove a liquid from a vessel that has no opening at the bottom and cannot be tipped.
3. To remove a liquid from a vessel when it is desired not to disturb a sediment at the bottom of the vessel.

VIII. Control of the Water Supply.—The water supply in the home is controlled by

A. *Faucets.*—These contain "washers" which must be renewed occasionally. Dripping faucets cause an annual waste of large quantities of water.

B. *Traps.*—Traps contain a *U*-shaped water seal which prevents sewer gas from entering the home.

C. *Flushing Tanks.*—These hold water for flushing toilets.

IX. Impurities.—Natural water may contain the following impurities:

A. Human wastes or sewage.

B. Bacteria.

C. Mud or clay.

D. Certain soluble mineral compounds, which may make the water "hard" or give it an objectionable taste.

E. Decaying vegetable matter.

X. Test for Impurities

A. Heat a small quantity of water in a flask, but do not boil. Shake the flask, remove the stopper, and smell the contents. If there is no odor, the water is pure.

B. Add a few drops of sulphuric acid to some water in a test tube and then add a few drops of potassium permanganate to color the water. Boil. If the color changes to brown, or if the mixture becomes colorless, decaying organic matter is present in the water.

> **Note.**—The presence of disease-producing bacteria in water can be detected only by trained bacteriologists.

XI. Purification of Water

Method	Impurities Removed
Filtration of water through sand and gravel.	Insoluble solids and bacteria.
Coagulation by the use of alum, followed by settling or sedimentation.	Mud and bacteria.
Chlorination. About 2 lbs. of chloride of lime are added to every million gallons of water.	Bacteria.
Boiling.	Gases and bacteria.
Aëration. The organic matter is oxidized by spraying the water into the air.	Substances that give the water an unpleasant odor or taste.
Distillation. The water is first vaporized and then condensed.	Practically all.

XII. Purification of Water by Filtration. (Demonstration)

Procedure	Observations and Conclusions
1. Fold a piece of filter paper so that it fits into a funnel. Pour some muddy water into the funnel, catching the water that runs through in a beaker.	The sediment remains on the filter paper. The water in the beaker is clear.
2. Remove the used filter paper from the funnel and replace it with a fresh piece. Pour sweetened or salty water into the funnel. Taste the filtered water.	The filtered water has the same taste as the substance which was dissolved. This shows that *soluble substances cannot be filtered out.*
3. Punch small holes in the bottom of a tin can. Cover the bottom with about 2 in. of gravel or coarse sand. On top of this, place a layer of fine sand, about 4 in. thick. Pour muddy water through this filter.	The water runs through free of mud.

> **Note.**—Spring and well water are filtered naturally through the soil.

XIII. Sewage.—Sewage consists of body wastes, washings from sinks, discharges from laundries, stables, and shops, washings from streets, etc. Sewage is dangerous because it is likely to contain the germs of intestinal diseases, such as dysentery, typhoid, cholera, and diarrhea.

XIV. Disposal of Sewage.—Sewage may be disposed of by

A. *Cesspools.*—These are excavations in which solid matter decays, and water drains into the soil. Cesspools are useful for rural homes.

B. *Septic Tanks.*—A septic tank consists of three watertight compartments made of cement. The sewage in a septic tank decays and liquefies before it is discharged into a neighboring stream.

C. *Discharge into large bodies of water and streams.*—This method is not sanitary, and is highly objectionable.

XV. Cleansing Action of Soap.—Soap aids in cleansing by forming an emulsion with the grease or oil, so that the dirt may be more readily removed by water.

> **Note.**—A mixture of small drops of oil with a soap solution is called a *permanent emulsion* because the drops of oil do not separate out from the rest of the liquid.

XVI. How to Make Soap. (Demonstration)

Procedure	Observations and Conclusion
Dissolve two teaspoonfuls of lye in a cup of warm water. Cool, and add a cup of melted lard or crisco. Heat to boiling, and stir until the mixture becomes thick. Cool for several hours, and then rub some of it in water.	The mixture hardens on cooling. It forms a lather when rubbed in water, showing that a fairly good soap was obtained.

XVII. Hard Water.—Hard water contains calcium and magnesium salts in solution. It does not form suds with soap; the soap merely combines with the salts, forming a sticky, insoluble scum. There are two kinds of hard water:

A. *Temporarily Hard Water.*—Contains the bicarbonate of calcium or magnesium in solution. It may be softened by boiling or by adding slaked lime.

B. *Permanently Hard Water.*—Contains in solution the chlorides or sulphates of calcium or magnesium. It cannot be softened by boiling. Washing soda, borax, or ammonia are commonly used for this purpose.

XVIII. How to Soften Hard Water. (Key demonstration)

Procedure	Observations and Conclusions
1. Add about 10 drops of liquid soap to half a glass of water. Shake well.	A copious lather is produced.
2. Dissolve a teaspoonful of salt in half a glass of water. Add soap as before.	A scum or sediment forms, but no lather. This shows that salts harden water and interfere with the action of soap.
3. Dissolve a teaspoonful of salt in half a glass of water containing a small quantity of borax or washing soda. Add soap as before.	A lather forms. This shows that borax or washing soda is a water softener.

QUESTIONS

1. Give five characteristics of water.

2. Explain how each of the following cities obtains its water supply: Chicago; Denver; Los Angeles.

3. (a) Explain how the force of gravity is utilized to bring water to the upper stories of a tall building. (b) Under what circumstances is an extra pumping system necessary?

4. (a) By means of labeled diagrams, describe the construction and operation of a lift pump. (b) Explain why the piston of the pump must not be more than 30 ft. above the level of the water in the well.

5. (a) Describe an experiment to illustrate the principle of water pressure. (b) What causes water to "seek its level"?

6. Describe two methods of testing for impurities in water.

7. (a) Describe four methods for sewage disposal. (b) Which method is best adapted for large cities? Give reasons for your answer.

8. (a) Describe five methods of purifying water. (b) Which methods are best adapted for the home? Why?

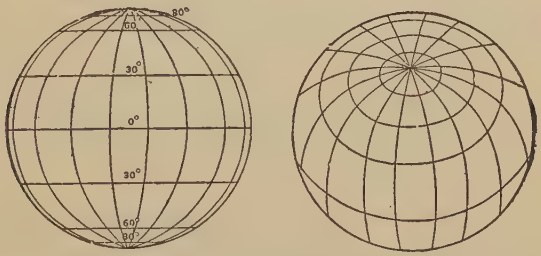
9. Describe a method of making soap in the laboratory.

10. Explain the cleansing action of soap.

CHAPTER VI

LOCATION, DIRECTION, AND TIME

I. Reference Lines.—In order to determine the exact location of a town or farm on land, or of a ship on the ocean, it is necessary to have a system of reference lines. In a well-laid out city it is easy to locate a given house by reference to numbered streets and avenues. Likewise, on a map or chart we can locate a given point by reference to numbered *meridians* and *parallels of latitude.*



From Physiography for High Schools, *Henry Holt & Co.*

Fig. 23.—Parallels and Meridians on a Globe.

II. Kinds of Reference Lines (Fig. 23)

A. *Axis of Rotation.*—The axis of rotation is an imaginary line on which the earth rotates. Its ends are the north and south poles.

B. *The Equator.*—The equator is a great circle midway between the two poles and at right angles to the axis of rotation. As its name implies, it divides the earth into two equal parts.

C. *Meridian Circles.*—Meridian circles are great circles passing through the poles and at right angles to the equator. A *meridian* is one-half of a meridian circle having its terminals at the poles.

D. *Parallels of Latitude.*—Parallels of latitude are circles drawn on the surface of the earth, parallel to the equator. These circles diminish in size as we approach either pole.

III. The Prime Meridian.—Owing to the fact that England played a very prominent part in the development of world trade, it became the custom of measuring distances east or west of the meridian passing through Greenwich, a suburb of London, which has a prominent astronomical observatory This meridian is known as the *prime meridian.*

IV. Latitude.—The latitude of a given place is its distance north or south of the equator, measured in degrees along a meridian.

V. Longitude.—The longitude of a given place is its distance east or west of the prime meridian, measured in degrees along a parallel of latitude.

> **Note.**—The location of any place on the surface of the earth is known if its latitude and longitude are known.

VI. Calculation of Latitude.—The latitude of any given place, as, for example, the position of a ship at sea, may be determined from observations of the sun or stars.

A. In the day-time the *sextant,* a nautical instrument, is used to find the angle which the sun makes with the horizon at noon.

B. This angle is corrected for the time of the year, and the latitude is determined by referring to certain charts.

C. At night, when observations of the sun cannot be made, a mariner determines his position in terms of latitude by making certain observations of the North Star, or of some other heavenly body.

VII. Calculation of Longitude.—The longitude of any given place is determined with the aid of a *sextant* and a *chronometer*.

A. Find local noon time by the use of a sextant.
B. The chronometer gives the exact Greenwich time.
C. Since the earth rotates on its axis through an angle of 15° every hour, the difference (in hours) between local time and Greenwich time, when multiplied by 15, gives the number of degrees of longitude east or west of Greenwich.

> **Problem.**—A mariner observes the meridian passage of the sun (at noon). The chronometer indicates 2 P.M. Greenwich time. What is the longitude?
>
> **Solution.**—The difference in time between that shown by the chronometer and Greenwich time is 2 hours. Since the earth rotates through an angle of 15° every hour, the longitude is $2 \times 15° = 30°$. Since, in this case, Greenwich time is later than local time, the mariner is in **longitude 30° west.**

VIII. Calculation of Time.—Time is calculated on the basis of the earth's movements.

A. *The Solar Day.*—The solar day is the time from noon to noon. Solar time varies with the longitude. At the equator the variation is 1 hour for a little over 1000 miles.
B. *Standard Time.*—Standard time is used to eliminate the confusion arising from the use of local solar

time. The United States is divided into four *time belts,* each of which covers 1 hour of time. Within these belts all clocks are set according to the central meridian of that belt (Fig. 24).

From Tarr and Von Engeln's NEW PHYSICAL GEOGRAPHY, *The Macmillan Co.*

FIG. 24.—TIME BELTS OF THE UNITED STATES.

C. *The International Date Line.*—The international date line follows, in general, the 180th meridian in the Pacific. When going west, a traveler *loses* a day when crossing the line; when going east, he *gains* a day. These corrections are made necessary by the gain or loss of time as one travels west or east.

D. *Daylight Saving Time.*—Daylight saving time is used in many communities during the summer months. In these places the clocks are set one hour ahead in order that an extra hour of daylight may be had for recreation after the day's work.

IX. Determination of Directions.—Directions on the earth's surface may be determined with the aid of

A. The magnetic compass.

B. Heavenly bodies, such as the sun or the North Star.

MAGNETISM

I. Natural Magnets.—Some iron ores, such as *magnetite,* possess the property of attracting small bits of iron. These ores are called *lodestones* or *natural magnets.*

II. Magnetic Substances.—If we bring a magnet near bits of wood, glass, copper, iron, steel, etc., we find that iron and steel are the only substances which the magnet attracts. For all practical purposes, iron (or steel, because of the iron in it) is the only magnetic substance.

III. Artificial Magnets.—When pieces of iron or steel are rubbed with lodestone, they acquire the power of attracting and holding iron filings, nails, and other bits of iron or steel. They retain their magnetism indefinitely and are called *artificial magnets.*

IV. Magnetic Poles

A. If we lay a sheet of paper on a bar magnet and sprinkle iron filings over it, we find that the filings cling most strongly at or near the *ends* of the magnet. The ends of a magnet at which the attraction is greatest are called the **poles** of the magnet.

B. If we suspend a bar magnet so that it is free to swing in a horizontal plane, it always comes to rest in a *north* and *south* direction. The end of the magnet which points north is called the **north pole** of the magnet; the other end is called the **south pole.**

V. Mutual Action of Magnetic Poles.—If the north pole of a bar magnet is brought near the north pole of another

bar magnet which is suspended so that it is free to swing in a horizontal plane, the north poles of the two magnets will *repel* each other. Similarly, the two south poles will repel each other. But if the south pole of one magnet is brought near the north pole of the other, they will *attract* each other.

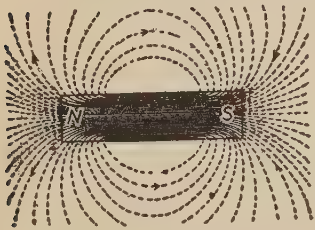
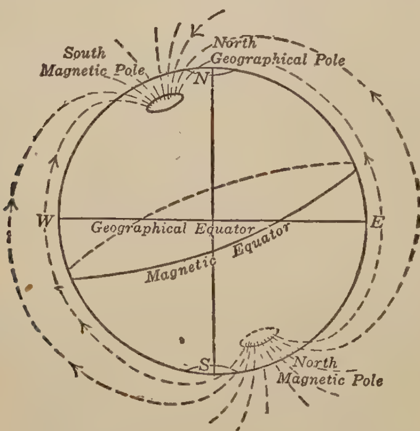


FIG. 25.—MAGNETIC FIELD OF A BAR MAGNET.

VI. Law of Magnetic Action. —*Like magnetic poles repel each other. Unlike magnetic poles attract each other.*



Courtesy, The Macmillan Co.

FIG. 26.—THE EARTH'S MAGNETIC FIELD.

VII. The Magnetic Field.—The space surrounding a magnet in which the magnet exerts its influence is called its *magnetic field* (Fig. 25). If a sheet of paper is placed over a bar magnet and iron filings are sprinkled over it, the filings map out the *lines of force* in the magnetic field.

VIII. The Magnetic Compass.—The magnetic compass is a device used in navigation and surveying to determine direction. It consists of a magnetic needle, pivoted so that it can turn freely in a horizontal plane.

IX. Declination.—Owing to the fact that the earth's magnetic poles do not coincide with its geographic poles, the compass does not everywhere point to the true north. The error, or *declination* of the compass is the number of degrees that the compass points east or west of the true north.

X. Compass Charts.—Since the compass does not everywhere point to the true north, the whole world has been charted to show the error of the compass at any given place.

QUESTIONS

1. (a) Explain how to make a compass. (b) Why does the compass needle always point north?
2. Give two proofs that the earth is a magnet.
3. *Define*: (a) magnetic substance; (b) natural magnet; (c) artificial magnet; (d) magnetic field.
4. (a) State two ways in which a mariner may determine his latitude. (b) Describe in detail one of these ways.
5. How does a mariner determine his longitude?
6. Discuss the importance of latitude and longitude in determining location.
7. (a) What is standard time? (b) Of what value is it?

CHAPTER VII

WORK AND MACHINES

I. Matter and Energy.—Our environment is made up of matter and energy. There is no form of matter that does not possess energy.

II. Properties of Matter.—The properties of a substance are the characteristics by which we identify that substance. Thus, table salt may be identified by its taste, ammonia by its odor, etc.

III. Physical Properties.—Physical properties are those properties which can be observed with our senses, such as color, odor, taste, hardness, solubility in water, etc.

IV. Chemical Properties.—Chemical properties are those properties which are connected with a chemical change.

> **Example.**—When wood burns, carbon dioxide is formed. The ability of the wood to burn is therefore a chemical property.

V. Energy.—The energy of a body is its capacity for doing work. Heat, sound, light, and electricity are different *forms* of energy.

VI. Potential Energy.—The energy which a body possesses because of its *position* or *condition* is called *potential energy.*

> **Examples.**—A lifted hammer, a heavy weight at the top of a pile-driver, a reservoir of water, a wound-up spring, a charged storage battery, all possess potential energy.

VII. Kinetic Energy.—The energy which a body possesses because it is moving is called *kinetic energy.*

> **Examples.**—The energy of a falling weight, of a moving bullet, of an unwinding spring, of expanding steam, etc., are examples of kinetic energy.
>
> **Note.**—Potential, or inactive energy, may become kinetic, or active energy, as when a wound-up spring is allowed to unwind.

VIII. Law of Conservation of Energy.—Energy can be changed from one form to any other form, but it can neither be created nor destroyed.

> **Illustration.**—Mechanical energy can be changed to electrical energy, chemical energy to heat energy, etc., without any loss.

IX. How Man Uses Various Forms of Energy. (Demonstration)

PROCEDURE	OBSERVATIONS
Pour water on the paddles of a water wheel.	The *falling water* makes the wheel turn.
Insert a wooden plug in one end of a spool. Fasten a pin-wheel firmly to the plug. Place the spool loosely on an iron rod as an axle. Fasten one end of a string to the spool and the other end to a very small weight. Wave a fan vigorously in front of the pin-wheel.	The *moving air* causes the pin-wheel to turn and thus lift the weight.

PROCEDURE	OBSERVATIONS
Bore a small hole near the bottom of an old coffee pot. Keeping the cover down, allow some illuminating gas to enter the pot through the hole. Bring a lighted match near the hole.	The *mixture of gas and air explodes,* causing the cover to fly back.
Balance a ruler on a low support. Place a weight on one end of the ruler. Drop a second weight from a height of about 1 ft. on the other end of the ruler.	The *falling weight* causes the first weight to be thrown up a short distance.

X. Force.—Force is whatever produces or tends to produce motion. It is either a *push* or a *pull,* and is usually measured in pounds. A pound of force represents the pull of gravity on a weight of one pound.

XI. Work.—Whenever a force acts upon a body in such a manner that it causes the body to *move,* it is said to do *work* upon that body. Thus, a person lifting a weight is doing work against gravity; a horse pulling a cart is doing work against friction.

> **Note.**—Do not confuse the technical meaning of *work* with its meaning in everyday speech. Supporting a weight, no matter how tiring, is not doing work. No matter how hard a horse pulls on a cart, if for any reason the cart does not move, no work is done.

XII. Measurement of Work.—Work is measured by the product of the force and the distance through which it acts. If W = work, F = force, and s = distance through which the force acts,

$$\mathbf{W} = \mathbf{F} \times \mathbf{s}$$

The unit of work most commonly used is the **foot-pound.** It represents the work done by a force of 1 lb. acting through a distance of 1 ft.

Problem.—A man lifts a mass of 20 lbs. through a distance of 5 ft. How much work does he do?

Solution

$$W = F \times s$$
$$W = 20 \text{ lbs.} \times 5 \text{ ft.}$$
$$W = \mathbf{100 \text{ ft.-lbs.}}$$

XIII. Work Independent of Time.—The amount of work done is independent of the time it takes to do the work. Exactly the same amount of work is done by a large engine pumping 1000 gallons of water as is done by a man working with a hand pump.

XIV. Power.—Power is the *rate* of doing work, or the amount of work done in a unit of time. It is determined by dividing the amount of work done by the time taken to do it.

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

The unit of power most commonly used is the **horse power.** A horse power is the rate of working that will accomplish 33,000 foot-pounds of work in 1 minute (550 foot-pounds in 1 second).

Problem.—What is the horse power of a steam engine that raises 90 tons 110 ft. high in 5 minutes?

Solution

$$\text{H. P.} = \frac{90 \times 2000 \text{ lbs.} \times 110 \text{ ft.}}{33{,}000 \times 5 \text{ min.}} = \mathbf{120}$$

MACHINES

I. Machines.—A machine is a device designed to transform or transfer energy. Machines are used

A. To increase the magnitude of a force.
B. To change the direction of a force.
C. To increase speed.

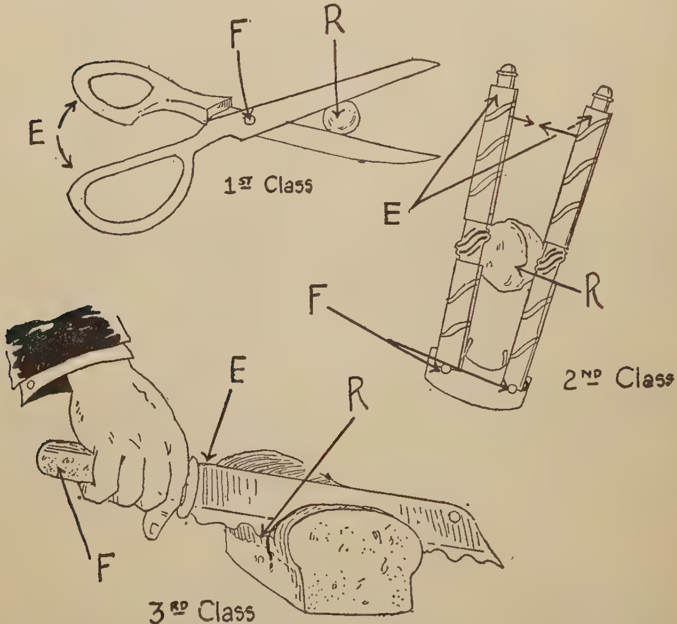


FIG. 27.—EXAMPLES OF THE THREE CLASSES OF LEVERS USED IN THE HOME.

II. Simple Machines.—There are only six *simple* machines. All other machines, no matter how complex, are combinations of two or more simple machines. The simple machines are

A. The lever.
B. The wheel and axle.
C. The inclined plane.
D. The pulley.
E. The wedge.
F. The screw.

III. Mechanical Advantage of a Machine.—The force that makes a machine work is called the *effort;* that which is exerted by the machine, the *resistance.* The ratio of the resistance (R) to the applied force (E) is called the *mechanical advantage* of the machine.

> **Problem.**—By means of a set of pulleys, a man was able to lift a mass of 2000 lbs. by exerting an effort of 80 lbs. What is the mechanical advantage of the set of pulleys?
>
> **Solution**
>
> $$\text{Mechanical advantage} = \frac{R}{E} = \frac{2000 \text{ lbs.}}{80 \text{ lbs.}} = 25$$
>
> **Note.**—By means of a machine one may gain force *or* speed—never both together, and never a gain in power.

IV. The Lever.—The lever is a rigid rod arranged to rotate about a point called the *fulcrum.* There are three classes of levers.

CLASS	RELATIVE POSITIONS OF EFFORT, FULCRUM AND RESISTANCE	ILLUSTRATIONS
First	The fulcrum is between the effort and the resistance.	Scissors, pliers, balances, claw-hammer, crowbar, pump-handle.
Second	The resistance is between the effort and the fulcrum.	Wheelbarrow, nut-cracker, foot-brake.
Third	The effort is between the resistance and the fulcrum.	Tongs, forearm, safety-valve rod, fishing-rod, oar, bread knife.

V. Law of the Lever.—*The effort multiplied by the effort arm is equal to the resistance multiplied by the resistance arm.* This law is illustrated by the following experiment:

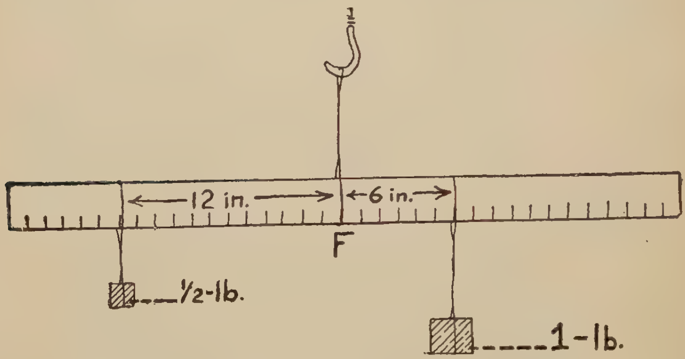


FIG. 28.—LAW OF THE LEVER.

PROCEDURE

Suspend a yard-stick from a hook so that it balances (Fig. 28). Hang a 1-lb. weight 6 in. from the balancing point or fulcrum. On the other side of the fulcrum hang a ½-lb. weight so that the yardstick balances again.

OBSERVATION AND CONCLUSION

The ½-lb. weight is found to be 12 in. from the fulcrum. The product of one weight and its distance from the fulcrum (½ lb. × 12 in.) is equal to the product of the other weight and its distance from the fulcrum (1 lb. × 6 in.).

VI. The Inclined Plane.—An inclined plane is any plane, rigid surface, placed so that one end is higher than the other (Fig. 29). It is easier to pull a weight up an inclined plane than it is to lift it vertically.

> **Example.**—A plank used to roll a barrel into a wagon; a winding road up a mountain side; a stairway, a wedge.

VII. Mechanical Advantage of an Inclined Plane.—The mechanical advantage of an inclined plane is equal to the ratio of the length of the plane to its height.

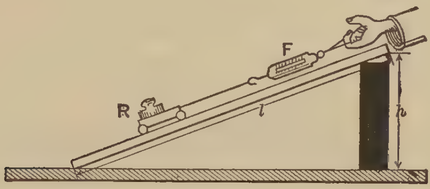


FIG. 29.—THE INCLINED PLANE.

Problem.—An inclined plane is 20 ft. long and 4 ft. high; what is its mechanical advantage?

Solution

$$\text{Mechanical advantage} = \frac{20 \text{ ft.}}{4 \text{ ft.}} = 5$$

VIII. How to Find the Mechanical Advantage of an Inclined Plane. (Demonstration)

PROCEDURE	OBSERVATION	CONCLUSION
Arrange a board 4 ft. long so that its upper end is 1 ft. from the table. Attach a spring balance to a weight and pull the weight slowly up the plane. Note the average reading of the spring balance.	A force slightly more than ¼ lb. is needed to pull the weight along the plane.	The mechanical advantage of the inclined plane is, by definition, 1 lb. ÷ ¼ lb. = 4. The ratio of the length of the plane to its height is also 4.

IX. Obstacles to Work

A. *Weight.*—The greater the weight of a body, the greater the force required to move it.

B. *Inertia.*—Inertia is the tendency of a body at rest to remain at rest, and of a body in motion to continue in motion. It is difficult to set a heavy body

in motion, and once it is moving, it is equally difficult to stop it.

C. *Friction.*—Friction is the resistance that must be overcome in order that one body may roll or slide over another. Friction may be lessened by the use of lubricants, ball-bearings, etc.

X. Advantages of Friction

A. We are able to walk because of the friction between our shoes and the pavement.

B. Nails and screws are held in place entirely by friction.

C. An automobile or a train is stopped by the brake as a result of friction.

D. A gasoline engine drives an automobile by friction between the tires and the pavement.

XI. What Is the Relation of Resistance to Work? (Experiment)

Procedure	Observations and Conclusions
Lift a 1-lb. weight by means of a spring balance.	The spring balance registers exactly 1 lb., showing that 1 lb. of force is required to overcome the resistance of a 1-lb. weight.
Place the 1-lb. weight on an inclined plane and pull it along the plane by means of the spring balance. Note the reading of the spring balance.	The spring balance registers less after the weight has begun to move than before it began to move. This shows that force is necessary to overcome the inertia of a body.
After the weight has begun to move, pull it slowly to the top of the plane. Note the reading of the spring balance while the weight is moving.	After inertia has been overcome, the spring balance still registers more than 1 lb., due to the friction between the weight and the plane.

Note.—The above experiment shows that the weight of a body, its inertia, and friction combine to offer resistance to work.

QUESTIONS

1. *Define*: matter; energy; power; work; horse power.

2. (a) Where do all forms of energy originate? (b) State and illustrate the Law of Conservation of Energy.

3. (a) What is a simple machine? (b) Name two simple machines. (c) Why are machines used?

4. What is meant by the *mechanical advantage* of a machine?

5. (a) What is a lever? (b) Distinguish between the three classes of levers, giving an example of each. (c) What is the *Law of Levers?*

6. Show how to calculate the mechanical advantage of an inclined plane.

7. (a) Name three obstacles to the efficiency of a machine. (b) How may one of these obstacles be partially overcome?

8. Mention several instances where friction is useful.

9. To which class does each of the following levers belong: fish-pole; can opener; nutcracker; pair of sugar tongs; claw of a hammer in pulling a nail; pump-handle?

10. (a) Name three simple machines used in the household. (b) Show how the energy needed to operate them came originally from the sun.

CHAPTER VIII

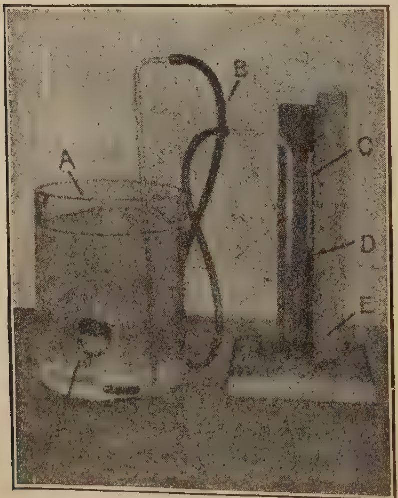
WATER AND ITS WORK

I. Water as an Agent of Work.—Water may be made to work for us because

A. It has weight and therefore exerts pressure. One cubic foot of water weighs 62.5 lbs.

B. It may be made to exert unbalanced pressure.

C. Like all other forms of matter, it has the property of *inertia; i.e.*, it tends to remain at rest when at rest, and to continue in motion when it is moving.



From Our Environment *by Wood and Carpenter, Allyn & Bacon*

Fig. 30.—Experiment to Show the Characteristics of Water Pressure.

II. What are the characteristics of water pressure? (Key experiment)

PROCEDURE	OBSERVATIONS AND CONCLUSIONS
Attach a thin rubber sheet to the mouth of a thistle tube (Fig. 30). Connect, by means of rubber tubing, the stem of the thistle tube to one arm of a *U*-tube containing some colored water.	The water is at the same level in both arms of the *U*-tube, because the air exerts the same pressure on the surface of the water in both arms.
Lower the thistle tube, mouth downward, in a jar of water. Turn it so that it faces sidewise, and finally upward.	The level of the water rises in the open arm of the *U*-tube, but does not change regardless of the position of the thistle tube. This proves that *water exerts pressure equally in all directions.*
Lower the thistle tube, mouth downward, to the bottom of the jar.	The level of the water in the open arm of the *U*-tube rises. This proves that *water pressure increases with the depth.*

III. How does a dam increase water pressure? (Experiment)

PROCEDURE	OBSERVATION AND CONCLUSION
Bore three small holes in the side of a one-gallon can, one above the other, and equally spaced. Fill the can with water, and note the force with which the water issues from each hole.	The water issues with the greatest force through the lowest hole. This explains how a dam builds up a tremendous water pressure by causing water to pile up to a great depth.

IV. What is the principle of flotation? (Experiment)

PROCEDURE	OBSERVATION AND CONCLUSION
Fill an overflow can with water until it is level with the spout. Weigh a small wooden block. Place the block in the overflow can, catching the displaced water in a beaker. Find the weight of the overflow.	The weight of the water that overflows is exactly equal to the weight of the wooden block. This proves that *a floating body displaces its own weight of the liquid in which it is floating.*

Note.—A ship's displacement is expressed in tonnage. Thus, if a ship and its cargo are rated at 40,000 tons, the ship displaces 40,000 tons of water.

V. The Aquaplane.—The aquaplane (water plane) illustrates how the inertia of water enables it to do work.

A. When an aquaplane is drawn rapidly through water, its front part being tilted highest, the inertia or resistance of the water piled under the front part of the plane tends to lift the plane and cause it to float (Fig. 31).

B. The resistance of the water increases witn the speed of the plane. The lifting force of the water under the plane is thus increased, and the front end of the plane is tilted still higher.

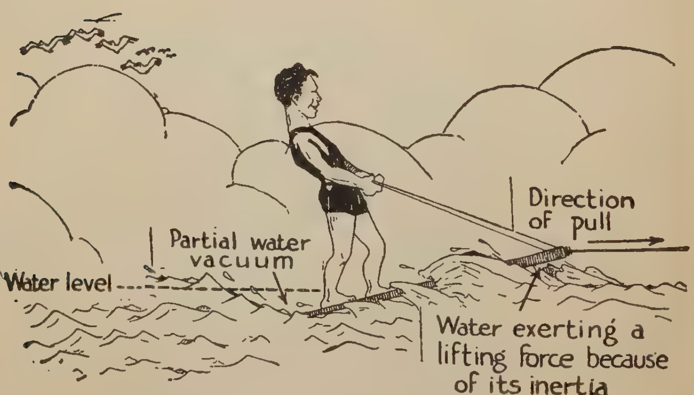


FIG. 31.—HOW AN AQUAPLANE FLOATS.

VI. The Work of Unbalanced Water

A. *Rapids and Waterfalls.*—The kinetic energy of the water in rapids and waterfalls turns water wheels which supply power for running machinery.

B. *Dams and Reservoirs*

1. The greater the depth of the water in a reservoir, or behind a dam, the greater the pressure exerted by the water.
2. This pressure, when released, is used to turn water wheels. In the case of elevated reservoirs, it forces water to the top of tall buildings.

C. *Tides*

1. The attraction exerted by the sun and the moon on bodies of water on the earth's surface causes water to pile up and thus become unbalanced in certain harbors and rivers.
2. This unbalanced water is made to do work by means of *inlet gates.* These gates are raised to permit water to enter, and are closed when the water is about to recede at change of tide. This leaves a reservoir of water at a high level; *i.e.,* unbalanced water capable of doing work.

QUESTIONS

1. (a) Why does water exert pressure? (b) How is this pressure measured?

2. (a) State two characteristics of water pressure. (b) Describe an experiment illustrating these characteristics.

3. Why did the United States build a dam at Keokuk and at Muscle Shoals? Explain the reason in terms of unbalanced water pressure.

4. Explain how an aquaplane may carry a load and remain afloat.

5. If 300 cubic feet of water fall each second from a height of 25 feet, (a) how many foot-pounds of work per second are available; (b) how many horse-power?

6. The hull of a modern battleship is made almost entirely of steel. Explain how the battleship can float.

7. Explain why a ship sinks if water runs in faster than the engines pump it out.

CHAPTER IX

AIR AND ITS WORK

I. Air as an Agent of Work.—Air may be made to work for us because

A. It has weight and therefore exerts pressure.
B. Its pressure is the same in all directions.
C. Its pressure may be readily unbalanced.
D. It is elastic and may be easily compressed.
E. It exerts energy when in motion.
F. It serves as a medium of communication.

II. Does air have weight? (Key experiment)

Procedure	Observation and Conclusion
By means of an air pump exhaust the air from a glass bulb provided with a stopcock. Weigh the bulb. Admit air into the bulb and weigh again.	The bulb is heavier when it contains air. This shows that *air has weight.*

Note.—Careful experiments show that 1 cu. ft. of air at 0°C. and 30-in. pressure weighs $1\frac{1}{4}$ ounces.

III. Measurement of Air Pressure.—Air pressure is measured by means of a barometer (page 24). At sea level, the pressure of the air is 14.7 lbs. (roughly, **15 lbs.) per sq. in.** This pressure is called *one atmosphere.*

IV. Is the pressure of the air equal in all directions? (Experiments)

Procedure	Observations and Conclusion
Blow up a rubber balloon and observe its shape.	The balloon assumes a spherical shape.

Procedure	Observations and Conclusion
Fill a tumbler with water and cover it tightly with a piece of stiff paper. Invert the tumbler cautiously, and hold it in various positions.	The paper is held in place, regardless of the position of the tumbler. Both of the above observations prove that *air exerts pressure equally in all directions.*

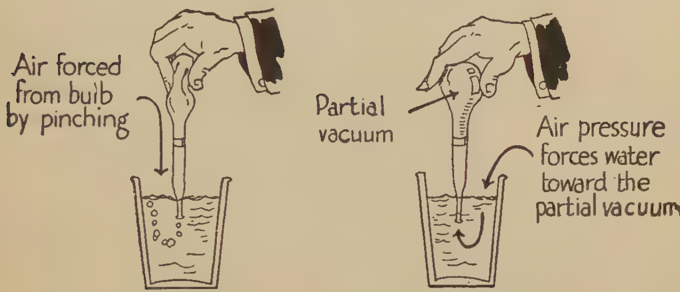


Fig. 32.—Unbalanced Air Pressure in Medicine Dropper.

V. Applications of Atmospheric Pressure

Device	How Air Pressure Is Unbalanced	Result
Medicine dropper	When the bulb is pressed, most of the air is driven out. When the tip is below the surface of the liquid, the bulb is released, thus creating a partial vacuum inside.	The greater pressure of the air on the surface of the liquid forces some of the liquid into the evacuated space in the medicine dropper.
Respiration	The raising of the ribs and the flattening of the diaphragm enlarges the chest cavity. The pressure of the air in the lungs is thus reduced.	Atmospheric pressure forces air into the lungs.

DEVICE	HOW AIR PRESSURE IS UNBALANCED	RESULT
"Soda straw"	The movement of the cheek muscles produces a partial vacuum in the mouth.	The greater pressure of the air on the "soda" forces some of it through the straw.
Kite	The kite is tilted at such an angle that the moving air (*wind*) flows under it, thus causing a compression below, and a partial vacuum above, the kite.	The compressed air below the kite exerts a lifting force, which tends to push the kite up into the partial vacuum above it.

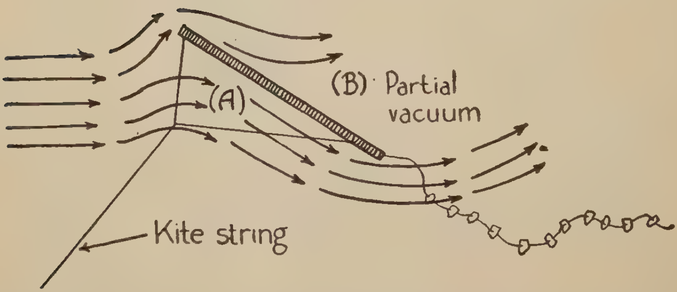


FIG. 33.—HOW A KITE FLIES.
The compressed air at (*A*) tends to lift the kite into the partial vacuum at (*B*).

Windmill	The vanes are set at an angle to the direction of the wind. The action of each vane is the same as that of a kite.	The compressed air in front of each vane tends to force the vane into the partial vacuum behind it.
Airplane	The motor pulls the airplane through the air, thus producing the same effect as that of moving [*Continued on page 71.*]	The compressed air underneath, and the partial vacuum above, each plane, [*Continued on page 71.*]

air. Each plane is tilted at such an angle that it strikes the air like a moving kite. tend to lift it and the airplane sails. The greater the speed of the airplane the greater the lifting effect.

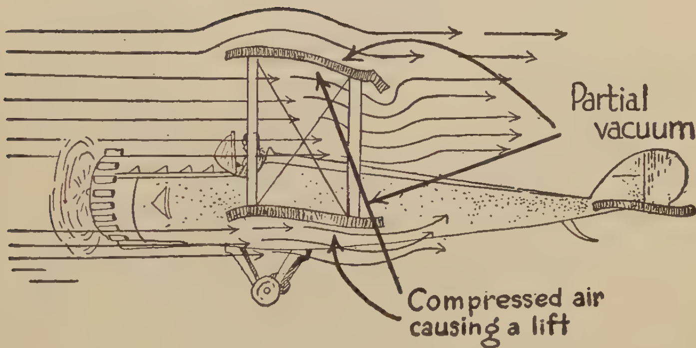


FIG. 34.—HOW AN AIRPLANE FLIES.

VI. Buoyancy of the Air.—An object appears to weigh less when it is submerged in a liquid than it does in air. The difference in weight is the same as the weight of the liquid which the object displaces. Similarly, an object appears to weigh less in air than it would in a vacuum by the weight of the air which it displaces. This is **Archimedes' Principle.**

VII. Application of Buoyancy to Balloons.—A balloon will

A. *Rise* when it weighs *less* than the air which it displaces.

B. *Sink* when it weighs *more* than the air which it displaces.

C. *Float* when its weight is exactly *equal* to the weight of the air which it displaces.

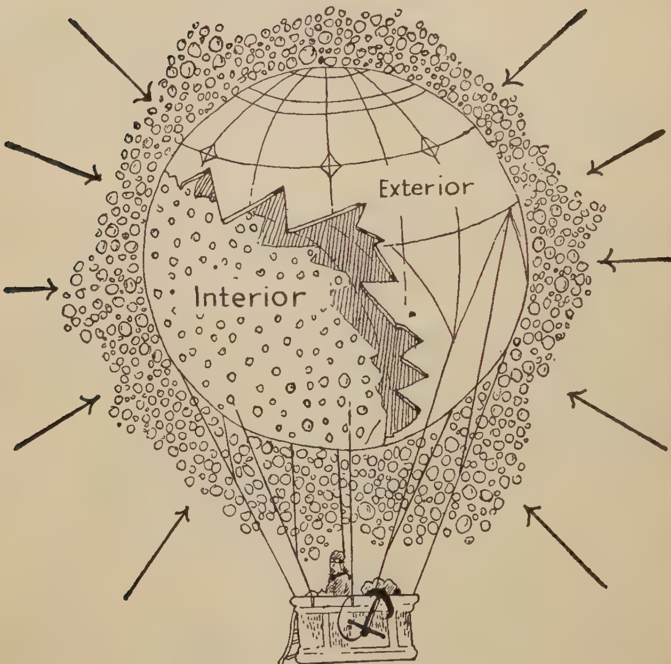


FIG. 35.—SECTION OF A BALLOON.

The weight of the air displaced by a balloon is greater than the weight of the balloon and the load it carries.

VIII. Uses of Compressed Air

DEVICE	OPERATION
Air gun	The sudden expansion of the compressed air forces the shot from the gun.
Caisson	Compressed air is forced into the chamber of the ***caisson***, thus preventing the entrance of water. This device enables men to work on the bottom of a river when laying the foundation of a bridge, etc

Device	Operation
Submarine	Compressed air drives water out of the air chambers. The submarine is thus made lighter than the volume of water which it displaces, and it rises to the surface. When water is allowed to enter the air chambers, the vessel becomes heavier and sinks below the surface.
Door-check	Air is compressed by a piston that operates as the door is swinging shut. This prevents the door from slamming.

IX. Sound.—Sound is caused by the rapid vibration of a body. When a person speaks, his vocal cords vibrate. When a banjo string is plucked, it gives forth a sound, and at the same time we can see that the string is vibrating.

X. The Cause of Sound. (Key demonstration)

Procedure	Observations
Strike the prongs of a tuning fork on the table and touch one of the prongs lightly to the water in a tumbler.	The tuning fork emits a sound. A spray of water is thrown from the prong, showing that the prongs are vibrating.
Hold one end of a small saw-blade with a pair of pliers. Snap the other end with a finger.	The saw-blade vibrates rapidly and emits a sound.

XI. What media transmit sound? (Experiments)

Medium	Experiment	Observations and Conclusions
Air (Gases)	Strike the prongs of a tuning fork and hold the fork about 1 ft. from your ear.	The tuning fork emits a sound. The vibration of the tuning fork has given rise to sound waves, which are *transmitted to the ear by the air.*

Medium	Experiment	Observations and Conclusions
Liquids	Tap two stones together, and note the intensity of the sound. Have a companion tap the same stones together under water, while you are listening under water.	The sound is much louder under water than it is in air. This shows that *liquids transmit sound better than gases.*
Solids	Hold your ear close to the top of a table and have a companion scratch the under-surface of the table with a pin.	The sound is heard very distinctly. *Solids transmit sound better than gases or liquids.*
Vacuum	Place an electric bell in a jar attached to an air pump. Set the bell ringing and gradually exhaust the air from the jar. Allow air to enter again slowly.	As the air is pumped out, the sound of the bell becomes fainter. When the air is re-admitted, the sound becomes gradually louder. This shows that *sound cannot be transmitted through a vacuum.*

XII. Speed of Sound.—Sound travels at different speeds in different media.

A. The speed of sound in air at 20° C. is approximately 1130 ft. per sec.

B. Sound travels faster in solids and liquids than in gases. In water the speed of sound is 4.5 times as great as in air; in steel it is 15 times as great as in air.

XIII. Musical Sounds and Noises

A. A *musical sound* is caused by regular, periodic vibrations with a frequency greater than 20 per second, and is pleasant to the ear.

B. A *noise* is a disagreeable sound caused by irregular, non-periodic vibrations, and also by slow periodic vibrations.

XIV. Properties of Musical Sounds

A. *Pitch.*—Pitch is the *highness* or *lowness* of a sound. The more rapid the vibration of the sounding body, the higher the pitch.

B. *Loudness.*—Loudness refers to the intensity of the vibrations that produce the sound.

C. *Quality.*—When a flute, violin, or harp is played behind a screen, one can determine from the *quality* of the sound which instrument is being played. Each musical instrument possesses a characteristic quality.

XV. Musical Instruments.—There are three types of musical instruments:

A. *Stringed Instruments.*—In stringed instruments, the strings are made to vibrate in various ways. In the violin and similar instruments a bow is drawn across the strings. In the banjo, harp, etc., the strings are plucked with the fingers. In the piano, small felt-covered hammers strike the wires. In all these instruments, sounding boards increase the intensity of the sound.

B. *Wind Instruments.*—A wind instrument is any instrument in which a vibrating column of air serves as the sounding body. The flute, bugle, cornet, and trombone are examples of wind instruments.

C. *Percussion Instruments.*—Percussion instruments produce a sound by the vibration of a membrane. The drum, kettle drum, and tambourine are examples of such instruments.

XVI. The Phonograph

A. In the phonograph, a needle follows an irregular groove in a revolving disc (*record*), and is thus set into rapid vibration.

B. The vibrations of the needle are communicated to a *diaphragm,* which is thrown into vibrations similar to those produced by the original sound recorded on the disc.

C. Sound waves are thus set up and, after being reënforced by the *sound box,* reach the outer air.

XVII. The Human Voice.—The human voice is produced by a combined string and wind "instrument."

A. Air expelled from the lungs makes the vocal cords vibrate. The vocal cords may be tightened at will by the contraction of certain muscles, thus producing notes of different pitch.

B. The bones, cartilage, and shape of the throat and mouth cavity aid in producing overtones which give the voice its characteristic quality.

XVIII. Structure of the Ear (Fig. 36)

A. *Outer Ear.*—A funnel-shaped organ adapted for concentrating sound waves on the tympanum.

B. *Tympanum.*—A thin membrane at the end of the outer ear, which vibrates when sound waves strike it.

C. *Middle Ear.*—A chamber beyond the tympanum containing three small bones (*hammer, anvil,* and *stirrup*), loosely connected. Vibrations of the tympanum are communicated to these bones, which are thus caused to vibrate in turn.

D. *Eustachian Tube.*—A tube leading from each middle ear to the back of the throat. This tube permits the free vibration of the tympanum, thus preventing injury from violent concussions.

E. *Inner Ear* (*Labyrinth* or *Cochlea*).—A structure in contact with the inner end of the three small bones. It contains many small nerve endings floating in a fluid. When these nerve endings are made to vibrate, sensations of sound are sent to the brain by the *auditory nerve.*

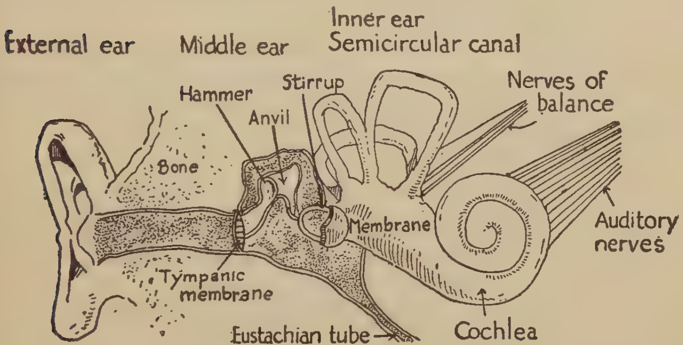


FIG. 36.—STRUCTURE OF THE HUMAN EAR.

XIX. Care of the Ears

A. Do not use a sharp object to clean the ears. The ear drums may thus be punctured, and deafness may result.

B. Clean the ears regularly to remove surplus wax, which interferes with proper hearing.

C. Do not neglect colds. Inflammation resulting from colds may attack the Eustachian tubes and cause deafness. *Mastoiditis* may result from inflammation of the middle ear.

QUESTIONS

1. (a) What is the average pressure of the atmosphere on one square inch of surface at sea level? (b) How are variations of air pressure measured?

2. Explain how unbalanced air pressure is furnished in nature.

3. Show how unbalanced air pressure may be obtained by means of a medicine dropper.

4. Explain how unbalanced air pressure is produced by a kite or an airplane.

5. (a) What is sound? (b) Name three necessary conditions for producing sound.

6. Explain how a phonograph works.

7. (a) Describe the structure of the ear. (b) Explain how the ear receives sound vibrations and transmits them to the brain.

8. Describe an experiment showing how sound waves may be produced.

9. Describe an experiment showing that media other than air may transmit sound waves.

10. Explain why the wind sometimes makes a "sighing" sound when it blows through the branches of a tree or through stretched telephone wires.

11. (a) Explain why a very violent noise may break the ear drum. (b) Why is it dangerous to box a person's ear?

12. A person can hear the sound of an approaching train better by placing his ear to the track. Explain.

13. (a) Mention three characteristics of musical sounds. (b) On what does each characteristic depend?

14. (a) What causes the difference between a musical sound and a noise? (b) What is the function of the wooden part of a violin in addition to its use as a frame to hold the strings?

15. *State*: (a) three ways of changing the pitch of the sound produced by a piano wire; (b) one way of changing the intensity of the sound.

CHAPTER X

HEAT AND ITS WORK

I. Nature of Heat.—Heat is a form of energy into which all other forms of energy may be converted.

A. When a moving body is brought to rest by friction or collision, its *kinetic energy* is converted into heat energy.

B. When a substance burns, the *chemical energy* is converted into heat energy.

C. When an electric current flows through a conductor, the *electrical energy* is converted into heat energy.

II. The Kinetic Theory of Heat.—The molecules of all substances are in constant motion. The nature and rate of this motion depend upon the nature of the substance, its state, and its temperature. *Heat is the kinetic energy of the molecules of a body.* An increase or decrease in the *rate* of motion of its molecules causes a corresponding increase or decrease in the amount of heat energy possessed by a body.

III. Sources of Heat

A. *The Sun.*—Directly or indirectly, the sun is the origin of nearly all the heat we receive.

B. *Burning of Fuels.*—This is the most important source of heat that we can control at will.

C. *Mechanical Energy*

1. *Friction.*—When the head of a match is rubbed on emery paper, it is heated by friction to its kindling temperature.

2. *Percussion.*—When a nail is driven into a piece of hard wood, the nail becomes hot.
3. *Compression.*—When we pump up a bicycle or automobile tire, the pump becomes hot.

D. *Chemical Energy.*—When sulphuric acid reacts with zinc, much heat is liberated.

E. *Electrical Energy.*—Heat is developed when an electric current moves against the resistance of a conductor, as in the electric light bulb, electric toaster, and other electrical devices.

IV. Effects of Heat on Matter

A. *Expansion.*—When a solid, liquid, or gas is heated, it expands. The heat increases the kinetic energy of the molecules, which are therefore driven farther apart from each other, thus causing the body as a whole to occupy more space.

B. *Change of State.*—When a solid is heated sufficiently it is converted into a liquid. Similarly, when a liquid is heated, it is converted into a gas.

V. How does heat affect matter? (Key experiments)

Experiment	Procedure and Observations	Other Illustrations
How does heat affect gases?	Fasten a toy balloon to the neck of a flask. Heat the flask gently. The balloon expands as a result of the expansion of the air in it. *Hence heat causes gases to expand.*	The expansion of air caused by the sun's heat gives rise to winds.

Experiment	Procedure and Observations	Other Illustrations
How does heat affect liquids?	Fit a flask with a one-hole rubber stopper, and fill the flask with colored water. Insert a narrow glass tube through the hole in the stopper. Heat the flask. Water is forced up into the glass tube. Hence *heat causes liquids to expand.*	Hot water heating systems are provided with an overflow pipe to allow for the expansion of the water when it is heated.
How does heat affect solids?	Fasten a strip of iron to a board. Heat the iron in the flame of a Bunsen burner. The strip of iron becomes longer, showing that *heat causes solids to expand.*	Steel railroad rails are laid with a small space between them to allow for expansion in summer and contraction in winter. Rivets are put in red hot so that, when they cool and contract, the metal plates are drawn firmly together.

VI. How Heat Is Transmitted.—Heat is transmitted from the place where it is generated to the place where it is usefully applied by the following methods:

A. *Conduction.*—Heat is transmitted through solids by molecular collision.

B. *Convection.*—When a liquid or a gas is heated, it expands and therefore becomes lighter. Gravity pulls the cooler and more condensed portions of the liquid or gas under the warmer and lighter portions, which are therefore pushed upward. Heat is transmitted through a liquid or a gas by movements of masses of the fluid.

C. *Radiation.*—Heat may be transmitted by ether waves, which are believed to fill all space.

VII. How is heat transmitted? (Key experiments)

Experiment	Procedure and Observations	Other Illustrations
Do solids transmit heat?	Heat one end of a metal rod in a Bunsen flame. The other end of the rod soon becomes too hot to hold. Hence *solids transmit heat by conduction.*	The iron of a stove or a steam radiator is heated by conduction.
Do liquids transmit heat?	Put some sawdust in a large beaker of water. Heat the beaker with a Bunsen burner. The motion of the sawdust shows that the water just above the flame moves upward. Hence a *liquid transmits heat by movements of masses of the liquid.*	A room is heated by convection currents of air. Winds are convection currents on a large scale.
Is heat transmitted through space?	Heat a flatiron and hold your hand below it, or to one side of it. The heat can be distinctly felt. The heat, in this case, is transmitted by invisible ether waves (*radiation*).	The heat and light of the sun reach the earth by radiation.

VIII. Conductors of Heat.—A substance is said to be a good *conductor* of heat if it readily permits heat to pass through it by conduction. The following metals are arranged in the order of their conductivity, silver being the best.

Conductors	Uses
Silver	Too expensive for general use.
Copper	In automobile radiators, coils for water heaters, boilers, etc.
Aluminum	In cooking utensils.
Iron	In stoves, radiators, boilers, etc.

Note.—In general, metals are good conductors of heat and non-metals are poor conductors.

IX. Insulators of Heat.—A substance is said to be a *heat insulator* if it resists the passage of heat through it by conduction.

Insulators	Applications
Asbestos	Insulating hot air flues, steam pipes, boilers, etc.
Cork, wool, felt	As packing for refrigerators, fireless cookers, etc.
Wood	Handles for cooking utensils, flat-irons, etc.
Woolen clothing	To keep us warm by preventing the escape of heat from our bodies.

Note.—The efficiency of cork, asbestos, fur, and woolen clothing as insulators is largely due to the air spaces which they enclose.

X. Heating Systems in the Home

Device	Advantages	Disadvantages
Fireplace (*radiation*)	Aids ventilation.	Not economical. Does not heat all rooms in house.

Device	Advantages	Disadvantages
Stove (*convection and radiation*)	Economical for small homes.	Heats only one room. Does not aid ventilation.
Hot air furnace (*convection*)	Cheap to install. Easily operated. Aids ventilation.	Poor distribution of heat on windy days. Dust and gas in rooms.
Steam boiler (*steam pressure, convection and radiation*)	Economical. Easily started.	Dust and gas in rooms. Noisy. Does not aid ventilation.
Hot water heater (*convection and radiation*)	Consumes less fuel. Maintains an even temperature.	Expensive to install. Does not aid ventilation.
Electric heater (*heated wires, convection and radiation*)	Clean and convenient.	Very expensive. Does not aid ventilation.

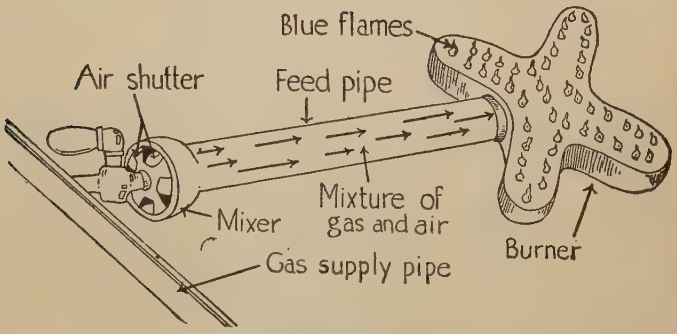
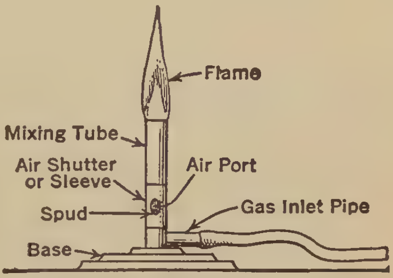


Fig. 37.—One Burner of a Gas Stove.

XI. Control of Heat in the Home.—In most heating devices used in the home, the heat is controlled by regulating the supply of air which the fire receives.

A. The heat in a stove is controlled by
   1. The *chimney damper*, which, when closed, checks the fire.
   2. The *opening* below the grate, which, when closed, checks the fire.

B. The flame of a gas range is controlled by the air shutter in front of the burner.
   1. When the shutter is closed, the gas is not completely burned. A yellow, smoky flame results.



From Our Environment *by Wood and Carpenter, Allyn & Bacon*

Fig. 38.—A Bunsen Burner.

   2. When the shutter is open, the gas receives a sufficient supply of oxygen for complete combustion, and thus gives a hot, blue flame.

XII. Conservation of Heat in the Home.—Much fuel is wasted by poor control of heating devices. Waste may be prevented, and heat conserved, by observing the following rules

1. Open the check draft damper to check the fire. Close it to increase the draft.
2. Keep the chimney damper almost closed.
3. Always keep the firing door closed.
4. Use the damper in the firing door only when burning soft coal. The gases liberated are thus oxidized.
5. Clean the ash pits daily.
6. Never shake a low fire before putting on fresh coal and giving it time to ignite.
7. Cover all heating pipes with asbestos cement.

8. In winter, use weather strips, storm doors, and storm windows.
9. Keep the temperature of living rooms between 68° and 70° F.
10. See that gas ranges always burn with a blue flame.
11. Cook food slowly over a low fire.
12. Use a fireless cooker.

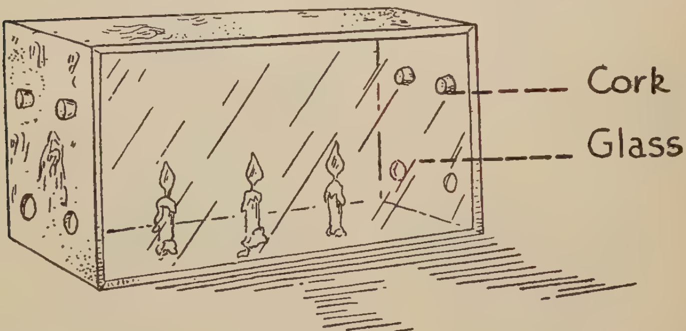


Fig. 39.—Experiment to Illustrate the Proper Method of Ventilating a Room.

XIII. Ventilation.—Air in a room where people congregate contains, besides bacteria and dust, carbon dioxide and other wastes given off by the human body. In addition to these substances, the air in a crowded room is hot and laden with moisture. Air in living rooms may be kept suitable for breathing by *ventilation.* The important factors of proper ventilation are

A. Circulation of air.
B. Proper humidity—between 40% and 60%.
C. Proper temperature—between 68° and 70° F.
D. Absence of disagreeable odors.

XIV. What is the best method of ventilating a room? (Key demonstration)

PROCEDURE	OBSERVATIONS AND CONCLUSIONS
1. Construct a box with a sliding glass front and bore four holes at each end. Place three candles in the box (Fig. 39).	
2. Light the candles, close the glass front, and close *all* the holes with corks.	The candles are extinguished in a short time.
3. Light the candles again, close the glass front, and remove the corks from the *lower* holes at *each* end of the box.	After a few minutes, the candles burn very dimly.
4. Close *all* the holes at *one end,* leaving all at the other end open.	The candles burn brightly. The cool, heavy air entering through the bottom holes pushes up the warmer, lighter air in the box and forces it out through the upper holes.

Note.—The ventilation box is a room on a small scale. Applying the conclusions of this experiment, it is clear that we can obtain a constant supply of fresh air by opening the windows in a room both at the top and bottom.

XV. Methods of Ventilation

A. *Natural Method.*—The windows are opened both top and bottom on the same side of the room. The temperature is kept at about 68° F. (Fig. 40A).

B. *Artificial Method.*—Air is heated to the right temperature and forced into the rooms by fans. The stagnant air is forced out through an opening near the floor (Fig. 40B).

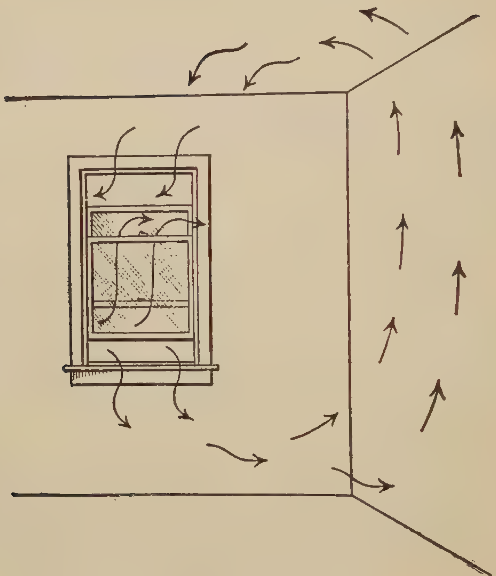


FIG. 40A.—NATURAL METHOD OF VENTILATION.

From OUR ENVIRONMENT *by Wood and Carpenter, Allyn & Bacon*

FIG. 40B.—ARTIFICIAL METHOD OF VENTILATION.

THE WORK OF HEAT IN INDUSTRIES

I. Importance of Heat in Industry.—Heat is of great importance in

A. The operation of various mechanical devices, such as the steam engine and gasoline engine.
B. The manufacture of illuminating gas.
C. The refining of petroleum.
D. The extraction of metals, such as iron, lead, and copper from their ores.

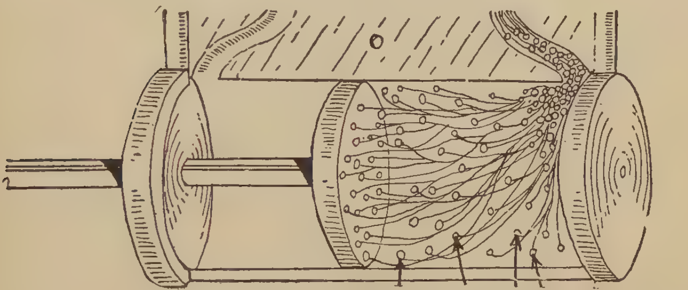


Fig. 41.

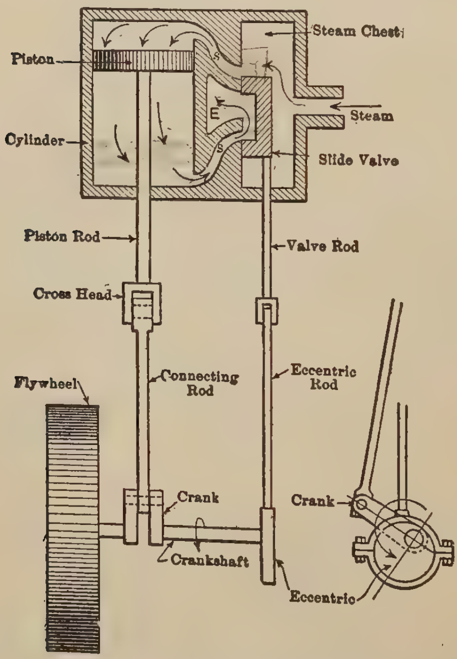
II. What is the source of energy in steam? (Experiment)

Procedure	Observation and Conclusion
Put a few drops of water in a test tube. Insert a cork loosely and heat. Keep the tube at arm's length and pointing *away* from you.	The cork is forced out of the test tube by the energy of the steam. The source of energy is the heat used in converting the water to steam.

III. The Steam Engine.—The steam engine was invented by James Watt, a Scotch instrument maker at the University of Glasgow.

A. *Construction.*—The following are the essential parts (Fig. 42):

1. A *cylinder* provided with a tight-fitting *piston.*
2. A *steam chest* containing a *slide valve.*
3. Openings (*ports*) *s*, *s*, and *E* for the admission and escape of steam.



From Elementary Principles of Physics *by Fuller, Brownlee and Baker, Allyn & Bacon*

Fig. 42.—The Steam Engine.

B. *Operation*

1. Steam under pressure enters the steam chest from the boiler. Finding the port *s* open, the steam flows into the cylinder and exerts pressure on the piston.

2. The piston moves forward (downward in the diagram), pushing the "dead" steam out of the cylinder through the port *s* and into the exhaust *E*.

3. The motion of the piston is communicated to the crankshaft through the connecting rod and crank. This motion is communicated, in turn, to the slide valve by means of the eccentric.

4. As the piston approaches the forward end of the cylinder (lower end in diagram), the slide valve moves over and changes the connections of the ports. Steam thus enters the forward end of the cylinder and drives the piston back.

IV. What is the source of energy in a gasoline engine? (Demonstration)

PROCEDURE	OBSERVATION AND CONCLUSION
Bore a small hole near the bottom of an old coffee pot. Pour a few drops of gasoline into the pot and cover loosely. Bring a lighted match near the hole.	The resulting explosion throws the cover off the pot. This shows that when gasoline vapor is mixed with air, an explosive mixture results.

Note.—In the automobile engine, the *carburetor* vaporizes the gasoline and mixes it with the proper amount of air.

V. The Gasoline Engine

A. *Construction.*—The following are the essential parts (Fig. 43):

1. A *cylinder* provided with a tight-fitting *piston.*
2. Two *valves* *V* and *V′* in the cylinder, one for the *intake* and the other for the *exhaust.*

B. *Operation*

1. *Intake.*—As the piston moves down (left in the diagram) on the first half stroke, valve V remains closed, valve V' opens, and a mixture of gas and air rushes into the cylinder.

2. *Compression.*—As the piston rises on the second half stroke, both valves remain closed and the gas is compressed. When the piston is near the top of the cylinder, an electric spark explodes the mixture.

3. *Ignition.*—The force of the explosion drives the piston down for the third half stroke, both valves remaining closed. This is known as the *power stroke.*

4. *Exhaust.*—As the piston rises on the fourth half stroke, valve V' remains closed, valve V opens, and the wastes are driven out through the exhaust.

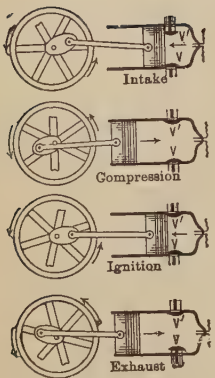


FIG. 43.—FOUR CYCLES OF A GAS ENGINE.

VI. The Automobile.—The gasoline engine furnishes the motive power for one of the most important means of transportation today—the automobile. The automobile illustrates the application of many scientific principles which you have learned or will learn. Some of these are:

A. Compressed air, in the tires.
B. Atmospheric pressure, which tends to prevent the tires from bursting.
C. Reflection of light, from the shiny surface of the body.
D. Electric energy, in the ignition system.
E. Elasticity, in the springs.
F. Friction, in the gripping of the ground by the tires.

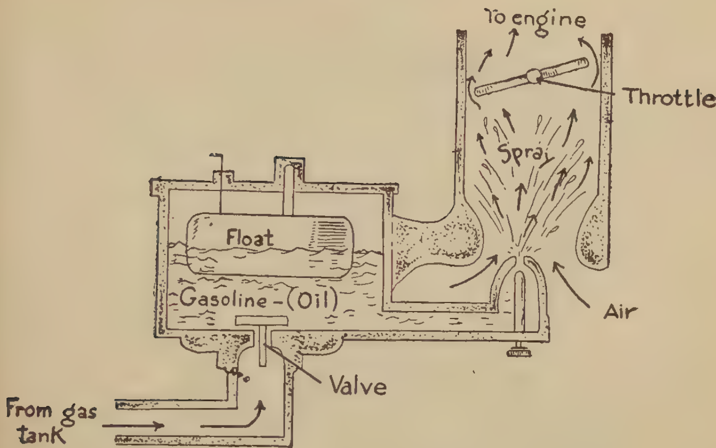


FIG. 44.—ACTION OF A CARBURETER OR "MIXER."

VII. The Systems in an Automobile.—The automobile is a very complex mechanism. It is composed of a number of systems, the breakdown of any one of which renders the automobile unfit for use. These systems are as follows:

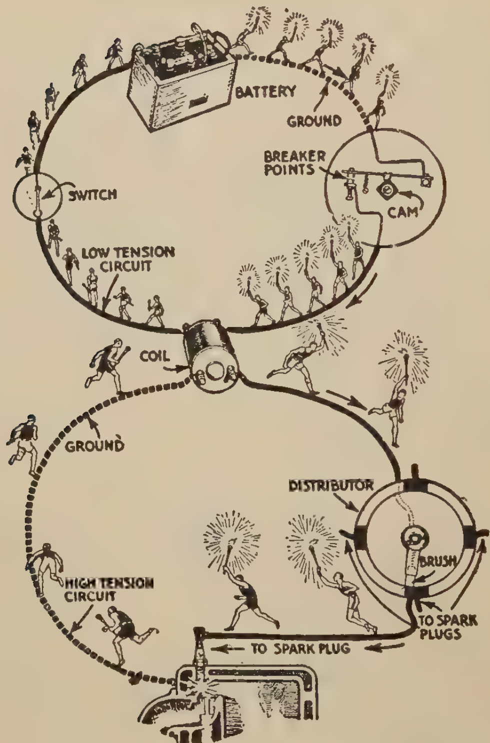
A. *The Chassis.*—The steel frame, the springs, and the wheels.

B. *The Body.*—The "superstructure" of the automobile.

C. *The Power Plant.*—The engine, electric system, and cooling system.

D. *The Transmission.*—The connecting system by which the power of the engine is transmitted to the wheels.

E. *The Controls.*—The instruments which enable the driver to start and stop, reverse, regulate speed, turn, etc.



Popular Science Monthly

Fig. 45.—The Ignition System.

VIII. Comparison of Steam Engine and Gasoline Engine

	Steam Engine	Gasoline Engine
Power	At every stroke of the piston.	Every fourth stroke of the piston.
	Gradually effective.	Effective only at the time of the explosion.
	From expanding steam.	From an expanding mixture of steam, carbon dioxide, and carbon monoxide.

	Steam Engine	Gasoline Engine
Where oxidation takes place	In the boiler.	In the cylinders.
Wastes of oxidation	Carbon dioxide and water vapor are driven out of the chimney. Ashes are left in the ash pit.	Water vapor, carbon dioxide, and carbon monoxide are driven out of the exhaust pipe.
Source of heat for kindling temperature	A match and kindling.	An electric spark.

IX. **Importance of Coal.**—Coal is our most important fuel. The following products are obtained by heating coal in retorts without access of air (*destructive distillation*):

A. *Coke.*—A valuable fuel. Burns with a hot, smokeless flame.
B. *Illuminating gas.*—Used for heating, lighting, and cooking.
C. *Ammonia.*—Used as a cleansing agent. Its compounds are used as fertilizers.
D. *Coal tar.*—Used in the manufacture of coal tar dyes, perfumes, drugs, and flavoring extracts.

X. **Petroleum.**—Petroleum is an excellent fuel. When distilled, it furnishes the following products:

A. *Gasoline.*—Used as a fuel in the gasoline engines of automobiles, airplanes, motor-boats, etc.
B. *Kerosene.*—Used for cooking and lighting.
C. *Lubricating oil.*—Used as a lubricant for machinery.
D. *Paraffin wax.*—Used for making candles.

XI. **Refining of Ores.**—An ore is a mineral from which an element, usually a metal, is extracted. The most common ores consist of the oxides, sulphides, and carbonates of metals.

A metal may be extracted from its ore by one of three methods:

A. *Reduction.*—The *oxide* is heated (*reduced*) with carbon (coke or charcoal). The carbon combines with the oxygen of the oxide, leaving the metal free:

Zinc oxide + Carbon → Zinc + Carbon monoxide

B. *Roasting.*—When a *carbonate* is heated (*roasted*), carbon dioxide is driven off, and the resulting oxide is reduced with carbon, as above:

Zinc carbonate + Heat → Zinc oxide + Carbon dioxide

C. *Electrolysis.*—The ore is decomposed by means of the electric current. Aluminum is made by this process.

XII. How are oxides reduced? (Experiment)

PROCEDURE	OBSERVATION AND CONCLUSION
Put a small piece of lead oxide in a cavity made in a piece of charcoal. By means of a blow-pipe, direct the flame of a Bunsen burner on the oxide.	Lead is left on the charcoal. The oxygen of the lead oxide has combined with the carbon of the charcoal, forming carbon dioxide.

QUESTIONS

1. (a) What are the effects of heat on matter? (b) Describe experiments illustrating these effects.
2. State three ways in which heat may be transmitted.
3. Explain how a hot-air heating system works. Use a diagram.
4. Furnaces and heater-pipes are often covered with asbestos cement. Explain.
5. Describe the best method of regulating the fire in a gas stove.
6. Mention five methods of preventing the waste of fuel. Give reasons.

7. To ventilate a room properly, the windows should be opened both top and bottom. Explain.

8. Explain how a fire in a grate creates a draft up the chimney.

9. (a) Name five products obtained from coal. (b) How are these products obtained?

10. (a) What is the source of the energy which steam possesses? (b) Illustrate by an experiment.

11. With the aid of a labeled diagram, describe the construction and operation of a steam engine.

12. With the aid of labeled diagrams, describe the construction and operation of a four-cycle gasoline engine.

13. (a) Compare steam with gasoline as a source of power. (b) Why is steam best suited for operating railroad engines?

14. (a) Explain how metals are extracted from their ores by means of heat. (b) Illustrate with examples.

15. Explain why a four-cylinder engine provides a more even supply of power than a one-cylinder engine.

CHAPTER XI

LIGHT AND ITS WORK

I. Light.—Light consists of those ether waves which are capable of causing the sensation of sight.

II. Characteristics of Light

A. It travels in straight lines.
B. Its speed is 186,000 miles per second.
C. It may be changed into heat energy when absorbed by a body.
D. It is not absorbed by the ether, hence sunlight does not heat outer space.

III. Does light travel in straight lines? (Key experiment)

PROCEDURE	OBSERVATION AND CONCLUSION
Bore a small hole in the exact center of each of two square pieces of cardboard (Fig. 46). Mount the cards separately on supports, and place them 2 ft. apart. Place a lighted candle in front of one cardboard, and observe the candle flame through both holes. Now move one cardboard several inches to one side and observe again.	When the cardboards are in line, only those rays of light that pass through both holes are visible. When one cardboard is moved aside, the candle flame is no longer visible through the holes. This proves that *light travels in straight lines*.

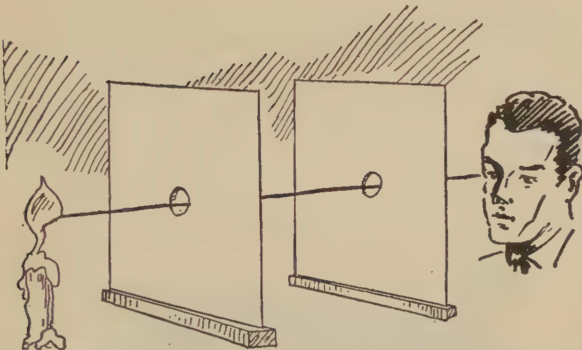


FIG. 46.—EXPERIMENT TO SHOW THAT LIGHT TRAVELS IN STRAIGHT LINES.

IV. Definitions

TERM	DEFINITION	ILLUSTRATIONS
Luminous body	A luminous body is one which is made visible by light generated within itself.	The sun; the stars; incandescent filaments.
Illuminated body	An illuminated body is one which is made visible by light which it receives from an outside source (*reflected light*).	The moon; the planets; your face.
Transparent body	A transparent body is one which permits light to pass through it so well that objects may be clearly seen through it.	Glass; clear quartz; water; alcohol; air.
Translucent body	A translucent body is one which permits light to pass through it, but diffuses this light so that objects cannot be clearly seen through it.	Ground glass; alabaster; waxed paper; egg shell.
Opaque body	An opaque body is one which does not permit light to pass through it.	Wood; granite; rubber; iron; silver.

V. Shadows.—When light strikes an opaque body it cannot pass through, and the space is darkened on the side of the opaque body away from the source of light. This darkened space is called a *shadow*. There are two parts in a shadow (Fig. 47):

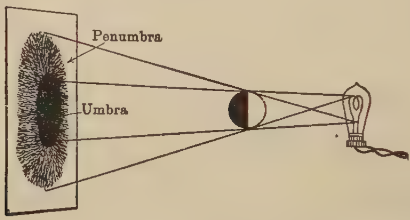


FIG. 47.—THE PARTS OF A SHADOW.

A. The *umbra* is the darker part of the shadow. It is produced by the total exclusion of light.
B. The *penumbra* is the lighter, outer portion of the shadow. It is produced by the partial exclusion of light.

FIG. 48.—THE ECLIPSE OF THE MOON.

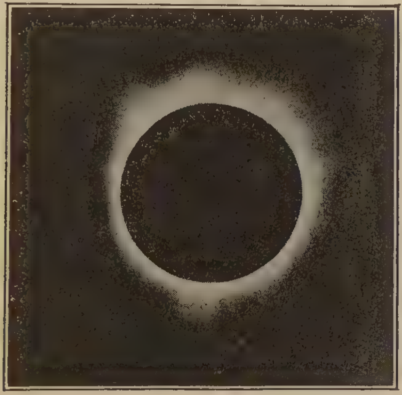
VI. Eclipses.—Shadows may be cast by the earth or the moon, causing *eclipses*.

A. *Eclipse of the Moon.*—A total or partial eclipse of the moon occurs when the sun, earth, and moon are in a straight line. When the moon passes into the dark shadow cast by the earth, it is said to be *eclipsed*.

From PHYSICS *by Fuller, Brownlee and Baker, Allyn & Bacon*

FIG. 49.—THE ECLIPSE OF THE SUN.

B. *Eclipse of the Sun.*—Whenever the moon is directly between the earth and the sun it casts a shadow on the earth and blots out the sun. The sun is then said to be eclipsed.



Popular Science Monthly

FIG. 50.—THE MOON BLOTTING OUT THE SUN.

VII. Reflection and Absorption of Light

A. *Regular reflection* occurs when light strikes a smooth, polished surface, such as a mirror or a brightly polished table top. The light which is sent back (*reflected*) from the surface is not scattered.

B. *Diffused reflection* occurs when light strikes a rough or unpolished surface, such as a rock or a wall. The reflected light is scattered.

C. *Absorption.*—When light strikes a black object, it is absorbed and more or less transformed into heat energy.

VIII. Refraction of Light.—Refraction is the bending of a ray or beam of light when it passes obliquely from one transparent medium into another of different optical density, as from air to water.

> **Examples.**—An oar partly submerged in water appears bent. Objects appear distorted when seen through ordinary window glass.

IX. The Spectrum.—When a beam of white light passes through a triangular glass prism, it is not only refracted but also *dispersed;* *i.e.*, separated into a series of different colors, called a *spectrum* (Fig. 51). The colors of the spectrum are violet, indigo, blue, green, yellow, orange, and red.

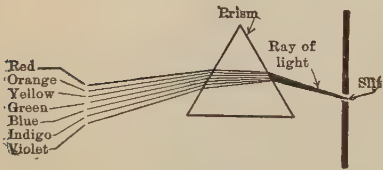


FIG. 51.—SPECTRUM FORMED BY A PRISM.

X. Color.—The color of an object depends upon the light which it *reflects* or *transmits.*

A. An object is white if it *reflects* most of the light that strikes it.

B. An object is blue if it absorbs all wave lengths of white light except the one that corresponds to blue, which it *reflects* to the eye.

C. An object appears black if it *absorbs* most of the light that strikes it.

D. A piece of glass appears red because it absorbs all wave lengths of the white light passing through it except the one which corresponds to red, which it *transmits* to the eye.

XI. Lenses.—A lens is a portion of a transparent material, usually glass, bounded by one or more curved surfaces.

A. *Kinds of Lenses*

1. *Convex Lenses.*—A convex lens is thicker at the center than at the edge.
2. *Concave Lenses.*—A concave lens is thinner at the center than at the edge.

B. *Uses of Lenses.*—Lenses are used in various optical devices, such as cameras, motion picture projectors, opera glasses, microscopes, telescopes, and eye-glasses.

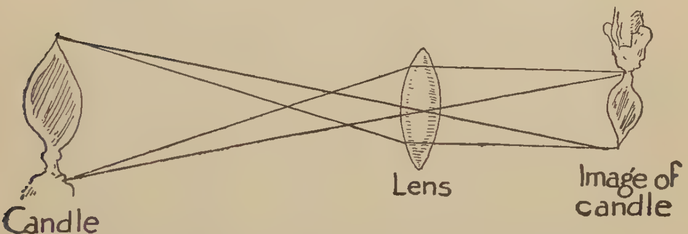


FIG. 52.—IMAGE OF A CANDLE FORMED BY A CONVEX LENS.

XII. What is the effect of a convex lens on light rays? (Experiment)

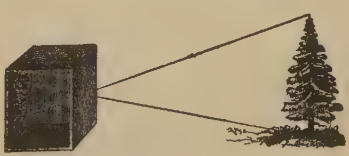
PROCEDURE

Place a convex lens between a lighted candle and a screen (Fig. 52). Move the lens back and forth until a clear image of the candle flame is seen on the screen.

OBSERVATION AND CONCLUSION

The image of the candle flame is inverted. A convex lens *converges* rays of light from an object to a focus, forming an *inverted image* of the object.

XIII. The Pin-hole Camera. — The pin-hole camera (Fig. 53) consists of a small box, painted black on the inside. It has a ground-glass screen on one side and a very small hole in the center



From PRACTICAL PHYSICS *by Carhart & Chute, Allyn & Bacon*

FIG. 53.—THE PIN-HOLE CAMERA.

of the opposite side. When an object is placed in front of the camera, an inverted image of the object is formed on the screen.

XIV. The Lens Camera.—This camera consists of a light-proof box blackened on the inside to absorb such stray rays of light as might possibly enter.

A. It has a *convex lens* at one end and a sensitive *film* or plate at the other end (Fig. 54).

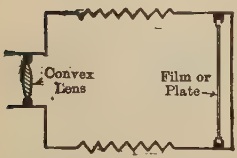


Fig. 54.—The Lens Camera.

B. Most cameras are constructed like a bellows, so that the lens can be moved forward or backward, according as we wish to photograph a distant object or a near object.

C. A *shutter* regulates the time of exposure of the film.

D. A *diaphragm* regulates the amount of light that enters through the lens.

XV. What is the action of light on a photographic film? (Experiment)

Procedure

Dissolve two or three crystals of silver nitrate in a little water, and add a few drops of potassium bromide solution. The yellow substance formed is *silver bromide*. Spread the silver bromide on a piece of blotting paper, and place on it a small object, such as a key. Expose to sunlight for about five minutes, or to a weak light for about ten minutes.

Observation

The silver bromide turns black only where the light strikes it. The resulting image of the key is called a *negative*. Silver bromide is the basic chemical used in making photographic films and plates.

XVI. The Human Eye.—The human eye closely resembles a camera. It consists of the following parts (Fig. 55):

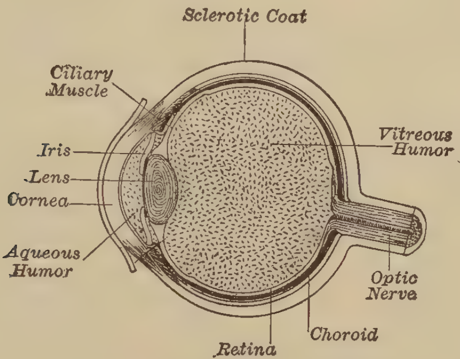


FIG. 55.—SECTION OF THE HUMAN EYE.

A. *Crystalline Lens.*—A dense, elastic, and transparent body. Its purpose is to focus images on the retina.

B. *Cornea.*—A transparent membrane serving as a protection for the exposed portion of the eye.

C. *Retina.*—The innermost layer of the eye, composed of nerve cells and almost transparent. It is connected with the brain by means of the *optic nerve*. Its function is to receive images of objects.

D. *Iris.*—The colored portion of the eye. Its function is to regulate the amount of light which enters. It contracts in bright light and enlarges in weak light.

E. *Pupil.*—The opening surrounded by the iris. Light enters through this opening.

F. *Ciliary Muscles.*—Small muscles which serve to focus the lens (*power of accomodation*).

G. Liquids are present in front and back of the lens. These liquids keep the eye firm.

XVII. Comparison of the Camera with the Eye

Function	Camera	Eye
To focus near and distant objects.	Lens—moved forward or backward.	Lens—can change its shape.
To receive the image.	"Negative" or plate—can take only one picture at a time.	Retina—may receive successive images.
To regulate the amount of light.	Diaphragm — may close or open.	Iris — may contract or relax.
To protect the machine.	Carrying case.	Eye-socket and eyelids.

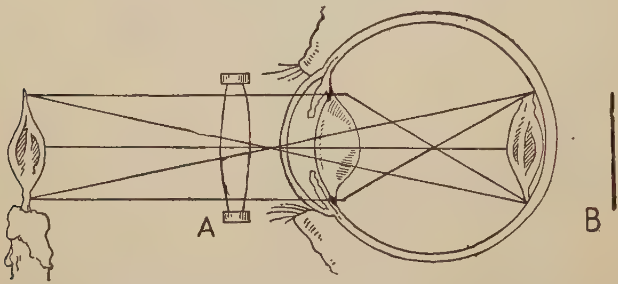


FIG. 56.—CORRECTION FOR FAR-SIGHTEDNESS.
The convex lens *A* brings the image from *B* to the retina.

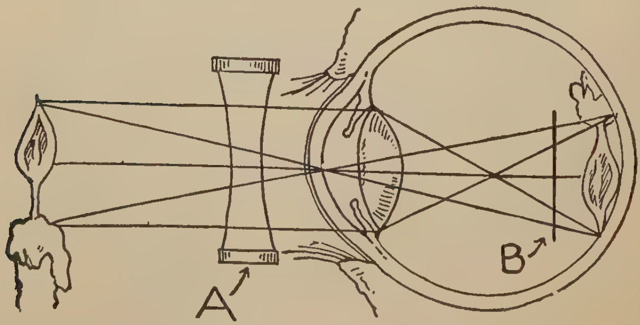


FIG. 57.—CORRECTION FOR NEAR-SIGHTEDNESS.
The concave lens *A* brings the image from *B* to the retina.

XVIII. Defects of Vision

Defect	Symptom	Cause	Corrected by
Far-sightedness	The person must hold the object farther from the eye than 10 in. to see it distinctly.	The lens of the eye is not sufficiently converging. The image is therefore brought to a focus *beyond* the retina.	Convex lenses as eye-glasses.
Near-sightedness	The person must hold the object much closer to the eye than 10 in. to see it distinctly.	The lens of the eye is too converging. The image is therefore brought to a focus in *front* of the retina.	Concave lenses as eye-glasses.
Astigmatism	The person cannot see horizontal, vertical, and oblique lines of an object equally distinctly.	Defective curvature of the lens. The image is not brought to a focus on horizontal and vertical lines at the same time.	Cylindrical lenses as eye-glasses.

XIX. Care of the Eyes

A. Do not read in a moving vehicle. The constant change in the focus of the eye as the page vibrates causes eye-strain.

B. Avoid reading very small print. The muscles of the lens are strained by the effort to bring the small letters into focus.

C. Avoid reading in a flickering light. The iris is strained in trying to adjust itself to the changing intensity of the light.

D. Light should strike the printed page from behind, over the shoulder.

E. Reading in too strong or too weak a light tires the eyes because the iris is strained in its efforts to vary the size of the pupil.

F. Do not rub the eyes to remove a foreign substance. Use an eye-wash, or turn the lid over with a match stick and remove the substance with a clean handkerchief.

XX. Artificial Light.—The chief sources of artificial light are candles, kerosene, gas, and electricity.

XXI. Flames.—The flame is the primary source of light in the candle and in kerosene and gas lamps. A flame is a burning gas. Solids and liquids must be at least partially changed to gases if a flame is to be produced by their burning.

A. Kerosene, gasoline, and alcohol simply vaporize. Paraffin melts and vaporizes.

B. Wood and soft coal are decomposed by the heat, and the volatile products produce a flame.

C. Coke and charcoal contain little volatile matter and therefore burn with practically no flame.

D. Hot particles of iron produce sparks but no flame. The iron does not vaporize.

XXII. Luminous and Non-Luminous Flames

A. *Luminous Flames.*—A luminous flame is produced when a substance burns in an insufficient supply of oxygen for complete combustion. This results in the presence of unburned, red-hot carbon particles.

B. *Non-Luminous Flames.*—Non-luminous flames are produced when there is a sufficient supply of oxygen for the complete combustion of the carbon present.

XXIII. Smoke.—Smoke consists of cooled carbon particles which have not been completely oxidized. It represents wasted fuel, and may be partly prevented by the use of devices which insure a sufficient supply of oxygen for the complete combustion of the fuel.

XXIV. Why do flames furnish light? (Experiment)

Procedure	Observations and Conclusion
Hold a piece of cold porcelain or a piece of chalk in the flame of a burning candle.	The porcelain or chalk becomes covered with soot. The soot consists of unburned particles of carbon which have been cooled below their kindling temperature.
Place some of the soot in the opening at the base of a lighted Bunsen burner.	The blue non-luminous flame changes into a yellow luminous flame. This occurs because the carbon particles (*soot*) become incandescent in the flame. Hence *a luminous flame is due to the presence of incandescent particles of carbon.*

XXV. How an Oil Lamp Works

A. The heat from a burning match ignites the wick and the oil in it.

B. More oil is brought to the top of the wick by capillary action.

C. Particles of carbon from the oil are heated to incandescence, thus producing a luminous flame.

D. The heated air in the chimney of the lamp is pushed up and out by cooler and heavier air. This gives rise to convection currents which bring fresh supplies of oxygen to the flame.

> **Note.**—The central portion of the flame of an oil lamp is deficient in oxygen; hence the carbon is not oxidized as rapidly as in a candle.

XXVI. The Gas Mantle.—The gas mantle operates essentially as follows:

A. A bag or mantle of *collodion* saturated with the oxides of the elements cerium and thorium is hung above a gas jet.

B. When the mantle is lighted, the collodion is burned off, leaving a very brittle coating of the oxides.

C. The burning gas heats the infusible mantle white-hot, thus producing a good source of light.

XXVII. The Incandescent Electric Lamp (Fig. 58)

A. The resistance of a thin filament of tungsten to the passage of the electric current through it causes it to become white-hot.

B. The air is removed from the bulb to prevent the oxidation of the filament.

C. The bulb is usually filled with either nitrogen or argon (inert elements) to prevent the evaporation of the tungsten filament.

XXVIII. The Electric Arc Lamp (Fig. 59)

A. A strong electric current is sent through two rods of carbon.

B. The intense white light produced is due to the white-hot particles of carbon in the arc and to the white-hot terminals of the rods.

C. When a direct current is used, the positive terminal is consumed about twice as fast as the negative terminal and assumes a crater-like shape. The negative terminal at the same time becomes cone-shaped.

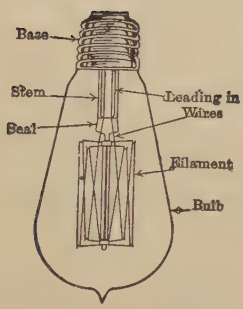


FIG. 58.—THE TUNGSTEN FILAMENT LAMP.

FIG. 59.—THE ARC LAMP.

XXIX. Safety Fuses.—An electric fuse is a safety device used to protect a building from fire.

A. The essential part of a fuse is a strip of lead or lead-alloy which melts at a low temperature.

B. When a "short circuit" occurs, the fuse melts and the circuit is broken.

Note.—Fuses are generally enclosed in a tube to prevent the melted lead from causing a fire.

XXX. Types of Artificial Illumination

A. *Direct Lighting.*—In direct lighting, the light is thrown directly down. This type of lighting is suitable for kitchens and bathrooms.

B. *Indirect Lighting.*—In indirect lighting, the light is thrown first to the ceiling, from which it is reflected downward. This type of lighting is pleasing and restful to the eye. It is used in churches, libraries, and public buildings.

C. *Semi-Direct Lighting.*—In semi-direct lighting, the light is thrown up to the ceiling, from which it is reflected down through a white glass shade. This type of lighting is used in schools, living rooms, and dining rooms.

QUESTIONS

1. Explain how an eclipse of the moon is caused. Use a diagram.

2. Describe an experiment to show the composition of white light.

3. Define *refraction.* Illustrate.

4. What factors determine the amount of sunlight in the home?

5. Compare the structure of the eye with that of a camera.

6. (a) State five rules for the proper care of the eyes. (b) Give the reason for each rule.

7. (a) What is a lens? (b) Describe two kinds of lenses, and state the purpose for which each kind is best suited.

8. Describe the operation of a pin-hole camera. Use a diagram.

9. (a) Why do some flames shine brilliantly, while others are but faintly luminous? (b) Which flames are the hotter? Why?

10. (a) Point out the differences between a mantle lamp and an incandescent lamp. (b) Why is it important that an electric lamp should contain no air?

11. Describe the construction and operation of an electric fuse.

12. Why are heat and light considered to be forms of energy?

13. (a) Discuss the advantages of direct, indirect, and semi-direct methods of lighting. (b) To which places is each method best adapted?

14. *Define and illustrate*: transparent body; luminous body; opaque body; translucent body; illuminated body.

15. Describe an experiment to show the direction in which rays of light travel.

CHAPTER XII

ELECTRICITY AND ITS WORK

I. Sources of Electricity.—There are three sources of electricity:

A. Friction.
B. Chemical action.
C. The dynamo.

II. Frictional Electricity.—Frictional or *static* electricity is electricity at rest.

A. *Positive Electricity.*—When a glass rod is rubbed with silk, it is said to have positive electricity or to be *positively charged.*
B. *Negative Electricity.*—When a rod of sealing wax is rubbed with fur or wool, it is said to have negative electricity, or to be *negatively charged.*

III. Laws of Electric Action

A. Like charges of electricity repel each other.
B. Unlike charges of electricity attract each other.

IV. Current Electricity.—Electricity produced by chemical action or by a dynamo is called *current electricity* because it may be made to travel through wires and perform useful work.

V. The Simple Voltaic Cell.—The voltaic cell is the simplest electric cell. It consists essentially of a strip of copper and a strip of zinc immersed in dilute sulphuric acid

(Fig. 60). When the two metal strips are connected by a wire, a current of electricity flows from the copper (*positive*) to the zinc (*negative*). The source of the electric current is the chemical action of the acid on the zinc.

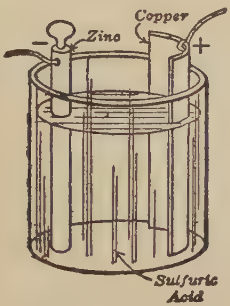
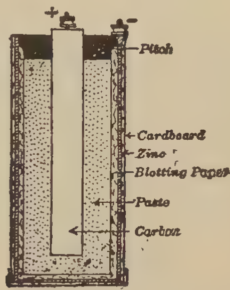


FIG. 60.—THE VOLTAIC CELL.



Courtesy The Macmillan Co.

FIG. 61.—THE DRY CELL.

VI. The Dry Cell.—The dry cell (Fig. 61) consists of the following essential parts:

A. A zinc container, which serves as the *negative* electrode.
B. A carbon rod, which serves as the *positive* electrode.
C. A paste composed of granulated carbon, manganese dioxide, ammonium chloride, zinc chloride, and water. This paste fills the space between the two electrodes.
D. A layer of pitch at the top to prevent the evaporation of the water.

VII. The Lead Storage Cell.—The lead storage cell consists of two lead plates immersed in dilute sulphuric acid in a suitable container.

A. It is *charged* by passing a current of electricity through it, thus causing certain chemical changes to take place.

B. When it is being *discharged,* the chemical changes are reversed, thus producing an electric current.

> **Note.**—The storage battery does *not* store up electricity, but *chemical* energy which is capable of producing electricity.

VIII. The Dynamo.—The dynamo or electric generator transforms mechanical energy into electrical energy. It may be operated in one of the following ways:

A. By means of water power, which is made to turn a turbine wheel connected with the dynamo.

B. By the burning of a fuel, usually coal, which drives an engine connected with the dynamo.

IX. The Principle of the Dynamo.—When a coil of wire is revolved between the poles of a magnet, a current of electricity is *induced* in the coil. During one half-turn of the revolving coil the current flows in one direction, and during the other half turn it flows in the opposite direction. Such a current is called an *alternating* current (A. C.).

> **Note.**—A current flowing in one direction is called a *direct* current (D. C.).

X. Essential Parts of a Dynamo

A. A *magnetic field* produced by permanent magnets or by electromagnets.

B. An *armature* consisting of a coil of copper wire wound around a soft-iron core, and arranged to rotate between the poles of the field magnet.

C. A device for collecting the current from the armature. This device consists of

1. Two *slip-rings* and *brushes* for an alternating current.
2. A *commutator* and *brushes* for a direct current.

XI. The Transformer.—The transformer (Fig. 62) is a device for *stepping up* or *stepping down* the voltage of an electric current.

A. *Essential Parts.*—Two coils of insulated wire are wound around a soft-iron ring. One of these coils (P) is the *primary,* and the other (S) is the secondary.

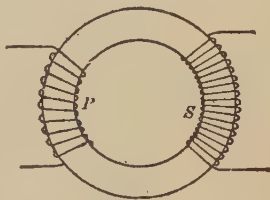


FIG. 62.—THE TRANSFORMER.

1. When the number of turns on the secondary exceeds the number of turns on the primary, the transformer is a *step-up* transformer.
2. When the number of turns on the secondary is less than the number of turns on the primary, the transformer is a *step-down* transformer.

B. *Uses.*—A current of comparatively low voltage is generated at the power station. It is then *stepped-up* for the transmission line by suitable transformers, and then *stepped-down* to a voltage which is safe enough for use in homes and factories.

XII. Measurement of Electricity

A. The **ampere** is the unit of current *strength.* Current strength is the quantity of electricity that passes a given point in a circuit in one second.

B. The **ohm** is the unit of *resistance.* It is the resistance offered by 160 ft. of ordinary lamp cord.

C. The **volt** is the unit of electrical *pressure.* It is that electrical pressure which is required to send a current of 1 ampere through a resistance of 1 ohm.

XIII. Ohm's Law.—The current strength in any circuit is directly proportional to the electromotive force (*electrical

pressure) and inversely proportional to the total resistance of the circuit:

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

XIV. Electric Power

A. Electric power is the energy expended by a given electric current in one second. The unit of electric power is the **watt.**

B. A watt is the rate at which energy is expended by a current of 1 ampere in that portion of a circuit the terminals of which have an electrical pressure of 1 volt.

$$1 \text{ watt} = 1 \text{ ampere} \times 1 \text{ volt}$$
$$\text{Watts} = \text{amperes} \times \text{volts}$$

≈ Kilo-

Note.—746 watts = 1 horse power.

XV. Energy Consumption.—The energy consumed when electrical devices, such as electric lights, vacuum cleaners, bread toasters, etc., are used is measured in **kilowatt-hours**:

$$\text{Kilowatt-hours} = \frac{\text{Volts} \times \text{amperes} \times \text{hours}}{1000}$$

Note.—We pay for the electricity we use on the basis of the number of kilowatt-hours consumed.

XVI. Water Current and Electric Current Compared

Water Current	Electric Current
A current of water flows through a pipe due to the pressure caused by a difference in water level. This pressure is measured in pounds per square inch.	A current of electricity flows through a conductor due to the pressure caused by a difference in the electric condition of the ends of the conductor (*potential difference*). This pressure is measured in *volts*.

Volts × Amperes

WATER CURRENT	ELECTRIC CURRENT
The rate of flow of a current of water is measured in gallons per second.	The rate of flow of a current of electricity is measured in *amperes.*
A current of water flowing through a pipe meets with resistance. The amount of resistance is determined by the length, diameter, and roughness of the inside surface of the pipe.	A current of electricity flowing through a conductor meets with resistance. The amount of resistance is determined by the length, diameter, and material of the conductor. This resistance is measured in *ohms.*

XVII. Effects of Electric Currents.—Electric currents may produce four different effects:

EFFECT	DESCRIPTION
Magnetic	A conductor through which a current of electricity is flowing is surrounded by a magnetic field.
Chemical	A current of electricity may cause chemical changes, as, for example, the breaking up of water into hydrogen and oxygen (*electrolysis*).
Thermal (heating)	When a current of electricity flows through a conductor, it is converted into heat energy. The heat energy may be converted, in turn, into light energy.
Physiological	When a current of electricity flows through the body, a tingling sensation is felt, muscles twitch, etc.

XVIII. Electroplating.—Electroplating is the process of coating or *plating* one metal with another by the use of the electric current. When iron or brass articles are coated with nickel, they are said to be "nickel-plated." When cheap jewelry is coated with gold or silver, it is said to be "gold-plated" or "silver-plated."

XIX. How to Copper-Plate. (Demonstration)

PROCEDURE	OBSERVATION
Prepare a solution of copper sulphate. Attach a clean strip of copper to a copper wire and connect the wire to the positive terminal of a dry cell. To another copper wire attach a clean silver coin, and connect this wire to the negative terminal of the dry cell. Submerge the strip of copper and the silver coin in the copper sulphate solution. Allow the current to flow through the solution for several minutes.	The silver coin becomes coated with copper. This copper must have come from the copper sulphate solution.

XX. Electrotyping.—Most books are printed from electrotype "plates." The following steps are involved in the making of electrotypes:

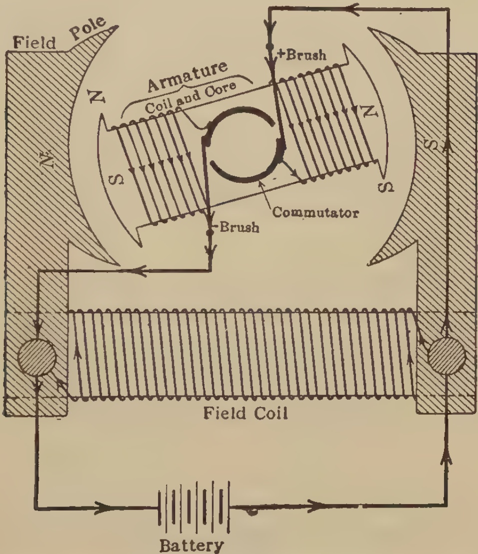
A. After the type is set, a wax impression is made of each page, so that each letter makes a sharp imprint on the wax mold.

B. The wax mold is then coated with powdered graphite to make it a conductor of electricity, and is suspended as the negative plate or *cathode* in a copper-plating solution. A plate of pure copper serves as the positive plate or *anode*. Copper sulphate is the *electrolyte*.

C. A current of electricity is then passed through the copper sulphate solution. The solution is decomposed or *electrolyzed*, and pure copper is carried to the mold, where it is deposited.

D. When sufficient copper has been deposited on the mold, the copper shell is removed and the wax is replaced with type metal to give the plate the required rigidity and strength.

XXI. The Electric Motor.—An electric motor is a machine which transforms electrical energy into mechanical energy. It is constructed like a direct-current dynamo, its essential parts being a *field magnet, armature, commutator,* and *brushes.*



From First Principles of Physics *by Fuller, Brownlee and Baker, Allyn & Bacon*

Fig. 63.—Circuit Diagram of Motor.

XXII. Action of a Direct Current Motor.—Fig. 63 shows diagrammatically a simplified form of motor.

A. When the current flows through the armature, the armature becomes a magnet with *N* and *S* poles.

B. Current flowing through the field magnet also produces *N* and *S* poles.

C. The *N* pole of the field magnet repels the *N* pole of the armature and attracts its *S* pole. At the same time, the *S* pole of the field magnet attracts the *N* pole of the armature and repels its *S* pole.

D. The mutual attraction and repulsion of the two magnetic fields turns the armature.

E. A *commutator* reverses the direction of the current in the armature at the exact moment when a pole of the armature reaches an unlike pole of the field magnet. The polarity of the armature is thus reversed, and the mutual attraction and repulsion of the two magnetic fields causes the entire process to be repeated.

> **Note.**—The speed of an electric motor is regulated by means of a *rheostat,* a device for increasing or decreasing the resistance.

XXIII. The Trolley

A. The electric current is generated by a dynamo, which may be many miles away. The dynamo is operated by steam or water power.

B. The trolley wire carries the current to an electric motor, which is geared to drive the wheels of the car. The trolley wire may be either strung on poles or laid under the street level.

C. The trolley pole makes contact with the trolley wire by means of a trolley wheel. Some electric cars obtain their current from a "third rail." Contact with the rail is made by means of sliding bars of metal (*brushes*).

D. The motorman regulates the current by means of a lever and resistance coils (*rheostat*).

THE USE OF ELECTRICITY IN COMMUNICATION

I. Communication by Electricity.—Some of our most important means of communication depend upon the electric current. The telegraph, the telephone, and radio (*wireless telephone*) all operate by means of electric energy. All these devices depend largely on the use of the electromagnet.

II. How to Make an Electromagnet. (Demonstration)

Procedure	Observations
Wind several coils of insulated wire around an iron nail and pass a current through the wire. Touch some steel tacks with one end of the nail. Lift the nail. Break the current in the wire.	The wire becomes a magnet when the current flows through it. The iron nail serves to reënforce the strength of the magnetic field. Breaking the current causes the coil to lose its magnetism, and the tacks drop off.

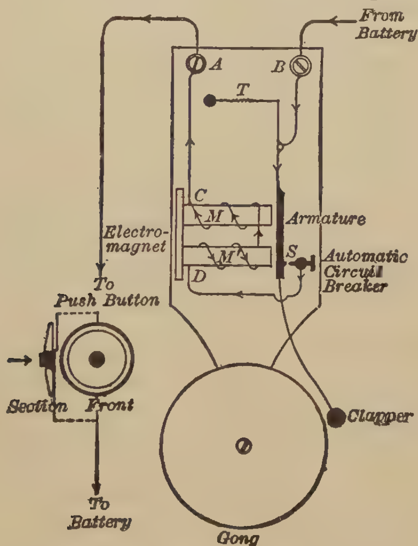


Fig. 64.—The Electric Bell.

III. Uses of Electromagnets.

III. Uses of Electromagnets.—Electromagnets are used

A. For handling steel in steel mills, for lifting kegs of nails, for lifting iron and steel on cars, etc.

B. In such electrical devices as the electric bell, telegraph, dynamo, motor, telephone, transformer, etc.

IV. The Electric Bell

A. *Construction.*—An electric bell (Fig. 64) consists of an electromagnet *MM'* opposite the poles of which

is a soft-iron armature. The armature is fastened to a spring T which is so adjusted that its tension is sufficient to keep the armature in contact with screw S when no current is flowing.

B. *Path of the Current:* From battery → binding post B → armature → screw S → coils of electromagnet → binding post A → battery.

C. *Operation.*—When the push-button is pressed, the circuit is closed.

1. The electromagnet is energized and attracts the armature. The clapper strikes the gong.
2. As the armature moves toward the electromagnet, it is no longer in contact with screw S, and the circuit is therefore broken.
3. The electromagnet no longer attracts the armature, and the spring T pulls the armature back so that it again makes contact with screw S. The process is then repeated.

V. The Telegraph.—The three most important telegraph instruments are the *key*, the *sounder*, and the *relay*.

VI. The Key.—The key (Fig. 65) is a device for sending messages by alternately *making* and *breaking* the circuit. It consists of a lever A pivoted at f, contact points C_1 and C_2, and a switch.

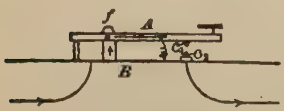


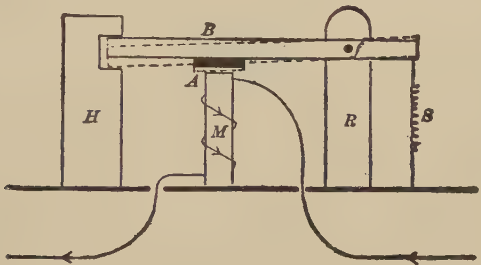
Fig. 65.—The Telegraph Key.

A. When the lever is depressed, contact is made and the circuit is complete. When the lever is raised, the circuit is broken.

B. The purpose of the switch is to close the circuit when the key is not in use.

VII. The Sounder.—The sounder (Fig. 66) is a device for making clicks. It consists of an electromagnet M above

which is a brass bar *B*, pivoted at *f*, and carrying a soft-iron armature *A*. *S* is a spiral spring.



From PHYSICS *by Cheston, D. C. Heath & Co.*

FIG. 66.—THE TELEGRAPH SOUNDER.

A. When the key is depressed, the circuit is complete, and current flows through the electromagnet *M*. The electromagnet attracts armature *A* and the rod *B* strikes against *H* with a clicking sound.

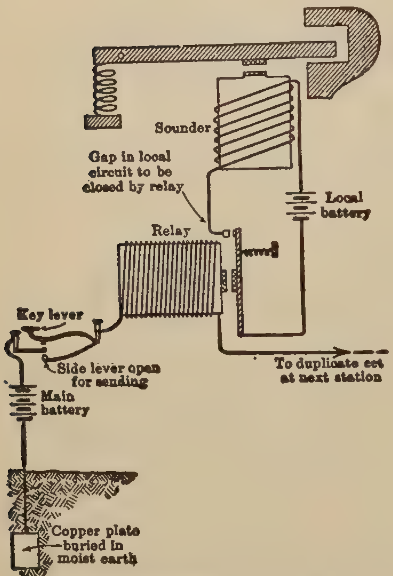
B. When the key is raised, the circuit is broken. The electromagnet releases the armature *A*, and the spring *S* pulls the rod *B* up, thus making another click.

> **Note.**—The *Morse Code* is a system of dots and dashes used to send messages by telegraph. A *dot* is a short interval between clicks; a *dash* is a long interval.

VIII. The Relay.—If the distance between stations is great, the resistance of the transmission line is very high and the current is therefore very weak. A *relay* is a sensitive instrument designed to pass messages on to a strong local current capable of operating a sounder. The relay consists of

A. A delicately adjusted electromagnet having a great many turns of wire so that it will respond to weak electric impulses (Fig. 67).

B. A delicately balanced armature placed in a vertical position in front of the electromagnet.



From First Principles of Physics *by Fuller, Brownlee and Baker, Allyn & Bacon*

Fig. 67.—One End of a Telegraph Line.

IX. Action of the Relay

A. When the sending key is depressed, the electromagnet attracts the armature, thereby closing the local circuit.

B. When the sending key is raised, the electromagnet releases the armature and the spring pulls it back to its original position, thus breaking the local circuit.

C. The alternate making and breaking of the circuit operates the sounder.

X. Plan of a Long-distance Telegraph System.—Fig. 67 shows the arrangement of instruments at one station of a long-distance telegraph system. To send a message

A. The operator first opens his switch, the switches in the other stations of the circuit remaining closed.

B. When he depresses the key, the relay armatures on the main line are attracted. The local circuits are

thus closed, and the armatures of the local sounders are pulled down.

C. When the key is raised, all the armatures are released and spring back to their original positions.

XI. The Telephone.—The telephone is an instrument for reproducing original sounds at a distance by means of the electric current. The essential parts of an electric telephone are

A. A transmitter.
B. A receiver.
C. An induction coil.
D. An electric battery.

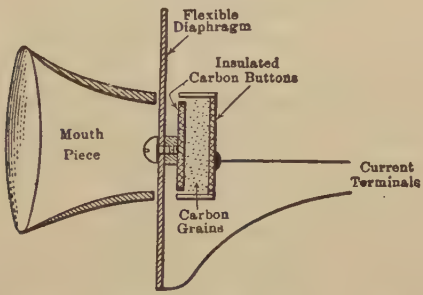


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Fig. 68.—The Telephone Transmitter.

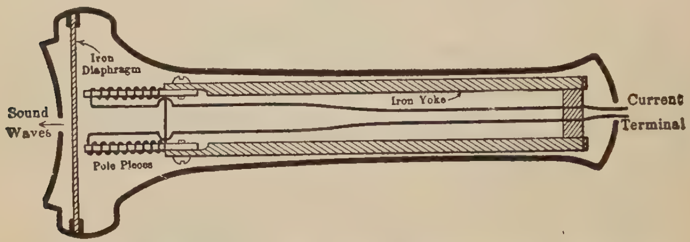
XII. The Transmitter.—The essential parts of the transmitter (Fig. 68) are

A. A flexible diaphragm.
B. A small carbon box filled with carbon granules.

XIII. The Receiver.—The essential parts of the receiver (Fig. 69) are

A. A steel *U*-shaped magnet having coils of fine insulated wire wound around each pole.
B. A soft-iron diaphragm, so supported that its center *almost* touches the ends of the magnet.

XIV. A Simple Telephone Circuit.—When a person talks into the transmitter, sound waves strike upon the flexible diaphragm and cause it to vibrate.



From FIRST PRINCIPLES OF PHYSICS *by Fuller, Brownlee and Baker, Allyn & Bacon*

FIG. 69.—THE TELEPHONE RECEIVER.

A. When the diaphragm is pushed inward, the pressure on the carbon granules is increased. The increase in pressure *reduces* the electrical resistance of the granules.

B. When the diaphragm springs back, the pressure on the carbon granules is reduced. The decrease in pressure *increases* the electrical resistance of the granules.

C. The varying resistance of the carbon granules causes continual fluctuations in the strength of the current.

D. The induction coil transforms the varying current from the transmitter into a rapidly alternating current, which is sent to the coils of the receiver magnet. The poles of the magnet are thus alternately strengthened and weakened.

E. The variations in the strength of the magnetic field set the diaphragm of the receiver into vibration. These vibrations correspond exactly to those of the diaphragm of the transmitter, and send out sound waves which reproduce the sound at the other end of the line.

XV. Radio.—Radio is the method of sending and receiving sound messages without the use of wires.

A. *Wireless telegraphy* is radio communication by means of a dot and dash code.
B. *Wireless telephony* is radio communication by the use of direct sound waves, such as the voice, music, etc.

XVI. The Radio Transmitter.—The radio transmitter consists of the following essential parts:

A. A *battery* or *dynamo* for furnishing the current.
B. A *key* for sending code messages, or a *microphone*, similar in construction to a telephone transmitter, for producing pulsations in the electric current.
C. A *generator* or *vacuum tube* for changing the electric pulsations from *audio-frequency* to *radio-frequency*.

> **Note.**—Audio-frequency vibrations range from 16 to 30,000 per second, and are audible to the human ear. Radio-frequency vibrations range up to many millions per second, and are inaudible.

D. *Induction coils* and *condensers* for "tuning" or varying the lengths of the radio waves produced.

> **Note.**—A wave-length is the distance from the crest of one wave to the crest of the next.

E. An *antenna* or *aërial* for dispersing the radio waves into space.

XVII. The Radio Receiver.—The radio receiver of the vacuum-tube type consists of the following essential parts:

A. An *antenna* for receiving the radio waves.

B. Tuning devices, such as *coils* and *condensers,* which cause the receiver to respond to the particular radio wave desired.

C. A *detector tube* for rectifying the high-frequency current from the antenna and converting it into audio-frequency vibrations.

D. Several *amplifier tubes* for increasing the strength of the signals, both before and after rectifying.

E. An *"A" battery* for heating the tube filaments.

F. Ear-phones or a loud speaker for changing audio-frequency waves into sound waves.

G. A *"B" battery* for supplying electric current to the earphones or loud speaker.

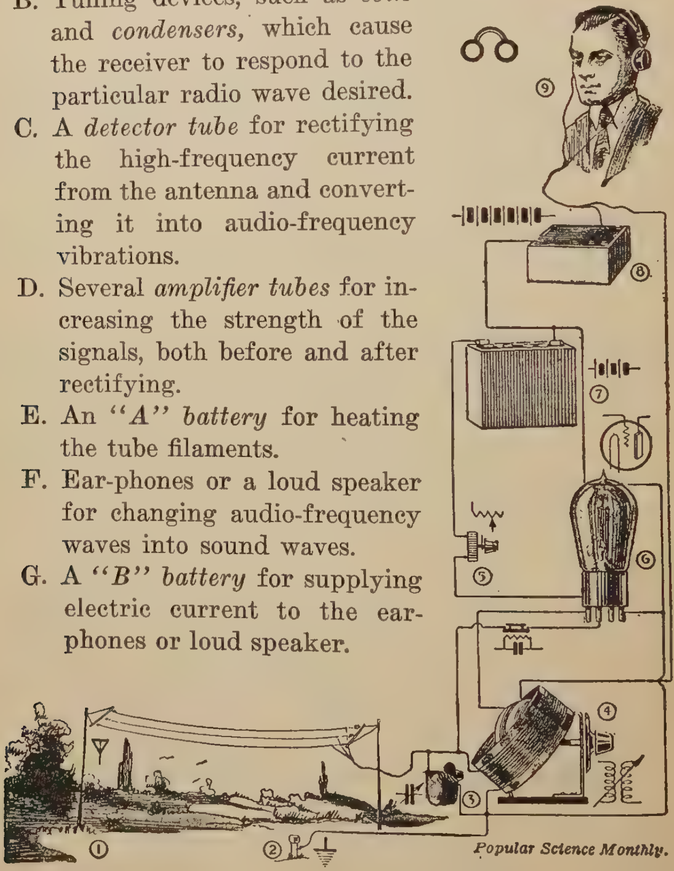


FIG. 70.—A VACUUM TUBE SET.

XVIII. Sound and Radio Waves Compared

	SOUND	RADIO
Origin	A vibrating body.	Electromagnetic vibrations in the ether.
Medium of transmission	Solids, liquids, and gases.	The ether.
Distance covered	Travel through a limited distance. Easily blocked by an obstruction. Cannot leave the earth's atmosphere.	Encircle the earth, and probably go into outer space. Pass through any obstruction.
Speed	In air, 1130 ft. per sec. at 20° C. Faster through solids and liquids.	186,000 miles per sec.
Frequency of vibration	From 16 per sec. (*low pitch*) to about 30,000 per sec. (*high pitch*).	Many millions per sec.
Wave-length	From about 70 ft. (*low pitch*) down to ¼–½ in. (*high pitch*).	From 30 ft. to 6 miles.

QUESTIONS

1. (a) What is static electricity? (b) Describe two simple methods of producing static electricity.

2. (a) Explain how to make a simple voltaic cell. (b) What is the difference between a voltaic cell and a dry cell?

3. Sketch an electric cell. Label all parts.

4. (a) What happens to a conductor when a current of electricity passes through it? (b) Prove that your answer is correct.

5. (a) Explain how to make an electromagnet. (b) Mention four devices which depend upon an electromagnet for their operation.

6. (a) Draw a diagram showing the construction of an ordinary electric bell with vibratory clapper. Label all the essential parts. (b) Describe the action of the bell.

7. (a) Describe a laboratory experiment to show the electrolysis of water. (b) Name the electrodes and the substance given off at each.

8. Explain how to copper-plate a spoon.

9. With the aid of a labeled diagram showing the essential parts, describe the construction and operation of a step-up transformer.

10. (a) Show by means of a labeled diagram the essential parts of a direct current generator (*dynamo*). (b) State the purpose of each part.

11. (a) Make a labeled diagram of an electric motor. (b) State the use of four of its essential parts. (c) Explain why the armature of the field rotates. (d) Explain why an electric motor is the reverse of a dynamo.

12. (a) With the aid of a labeled diagram, show the construction of a telephone transmitter and a telephone receiver connected together by a telephone line. (b) Explain, step by step, how the speaker's voice at the transmitter is reproduced by the receiver at the other end of the telephone line.

13. What are the chief differences between sound waves and radio waves?

14. (a) Explain what is meant by *radio-frequency*. (b) How may radio-frequency be modulated or changed so as to be audible?

15. Why is it necessary that different broadcasting stations send out their programs on different wave-lengths?

CHAPTER XIII

PLANTS AND SOIL

CELLS, TISSUES, AND ORGANS

I. Protoplasm.—Protoplasm is the living substance of which plants and animals are made up.

II. Chemical Composition of Protoplasm.—Protoplasm has a very complex chemical composition. In addition to the element nitrogen it contains the elements carbon, hydrogen, oxygen, phosphorus, and sulphur.

III. Physical Properties of Protoplasm

A. Granular.

B. Colorless or slightly gray.

C. Jelly-like or semi-fluid. It resembles the white of a raw egg.

IV. Physiological Properties of Protoplasm

A. *Irritability*—the ability to respond to influences or changes in its surroundings. For example, a plant grows towards light; an earthworm crawls away from light.

B. *Contractility*—the ability to perform some spontaneous movement.

C. *Assimilation*—the ability to change raw materials (*food*) into protoplasm. Assimilation must be preceded by the processes of—

1. *Digestion*—the changing of food into a soluble form so that it can be utilized by the organism.
2. *Absorption*—the process of taking digested foods from the alimentary canal into the blood.

D. *Respiration*—the process whereby oxygen is taken in and carbon dioxide is given off. The oxygen oxidizes the food, heat and energy are liberated, and the carbon dioxide is eliminated as a waste.

E. *Excretion*—the process by which wastes are eliminated.

F. *Growth*—results from the process of assimilation.

G. *Reproduction*—the production by an organism of another organism similar to itself.

FIG. 71.—DIAGRAM OF A PLANT CELL.

V. The Cell.—All living things, when examined under a compound microscope, are found to be made up of very small units called **cells**. Each cell consists of a tiny mass of protoplasm and a structure known as the **nucleus**. In plants, each

cell is surrounded by a **cell wall** made up of cellulose or wood. There are many kinds of cells, each having a different use or *function*.

> **Examples.**—Root cells, leaf cells, muscle cells, nerve cells.

VI. Structure of a Green Plant Cell

Part of Cell	Description and Location	Use
Cell wall	Composed of cellulose or woody material. Surrounds the cell.	For protection.
Cell membrane	Margin of protoplasm.	For protection in animal cells; for osmosis in plant and animal cells.
Nucleus	Denser portion in protoplasm. Generally oval in shape.	Principally for reproduction.
Cytoplasm	Protoplasm surrounding the nucleus.	For all life functions except reproduction.
Chromatin	Network in the nucleus.	Carries inherited traits.
Cell sap	Clear liquid in the cytoplasm.	Contains water, dissolved nutrients, and mineral salts.
Chlorophyll bodies	Green bodies in the cytoplasm.	Help make food for the plant.

VII. Cell Reproduction.—Each cell grows to a maximum size and then splits in two parts. The following steps are involved in this process:

A. The nucleus divides first.

B. The chromatin material forms small bodies called *chromosomes*.

C. One-half of each chromosome goes to each new cell.
D. The cytoplasm divides into two parts.
E. Two new cells, similar to the original cell, result.

VIII. Tissues.—A tissue is a group of adjoining cells, alike in shape, size, and function.

Examples.—Nerve tissue, muscle tissue, bone tissue.

IX. Organs.—An organ is a part of a living thing, made up of one or more tissues, which performs some definite function.

Examples.—Hand, heart, eye, root, stem, leaf.

X. Organism.—An organism is a living thing which is capable of living alone in its natural environment.

Examples.—Man, frog, bird, tree.

HOW PLANTS PRODUCE SEEDS AND FRUITS

I. Structure of a Green Plant.—Most green plants have the following parts:

Part	Function
Flowers	Form the seeds.
Seeds	Reproduce the plant.
Fruit	Protects the seeds and helps to disperse them.
Leaves	Manufacture food for the plant. Breathe.
Roots	Anchor the plant to the ground. Absorb water and dissolved minerals from the soil. Store food.
Stem	Holds the leaves up to the sun. Serves as a passageway between the leaves and the stem and roots.

II. General Structure of a Flower

A. *Floral Envelopes.*—Every complete flower has two floral envelopes, the *calyx* and the *corolla.*

1. *Calyx.*—The calyx is composed of *sepals*—small, green, leaflike parts covering the unopened flower. The sepals protect the flower while in the bud.
2. *Corolla.*—The corolla is made up of brightly colored leaflike structures called *petals.* The function of the petals is to attract insects to the flower.

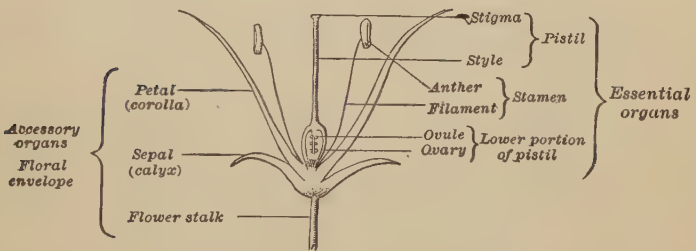


FIG. 72.—THE PARTS OF A FLOWER.

B. *Essential Organs.*—The essential organs of a flower are the *stamens* and the *pistils.*

1. *Stamen.*—The stamen is the male organ of the flower. It consists of the *anther,* a box-like structure, and the *filament,* the stalk of the stamen. The anther produces and holds *pollen grains.* The filament holds up the anther so that the pollen may scatter.
2. *Pistil.*—The pistil is the female organ of the flower. It consists of an enlarged base, the *ovary,* a stalklike structure, the *style,* and an enlarged tip, the *stigma.* The ovary produces and holds the *ovules.* The stigma receives pollen and starts it growing.

III. Pollination.—Pollination is the transfer of pollen from an anther to a stigma of a flower.

IV. Kinds of Pollination

A. *Self pollination*—the transfer of pollen from the anther to the stigma of the *same* flower.
B. *Cross pollination*—the transfer of pollen from the anther of one flower to the stigma of *another* flower of the same or closely related kind.
C. *Artificial pollination*—pollination by man.

V. Agents of Cross Pollination

A. Insects (bees, flies, butterflies, etc.).
B. Birds (*e.g.*, humming bird).
C. Wind.
D. Water.
E. Larger animals (including man).

VI. Advantages of Cross Pollination

A. Hardier plants result.
B. More seeds are produced.
C. The resulting plants are more *varied*.
D. New plants are produced. For example, plum and apricot, when crossed, produce *plumcot*.

VII. Development of Seed and Fruit

A. A stigma is pollinated.
B. The pollen grains germinate, producing pollen tubes.

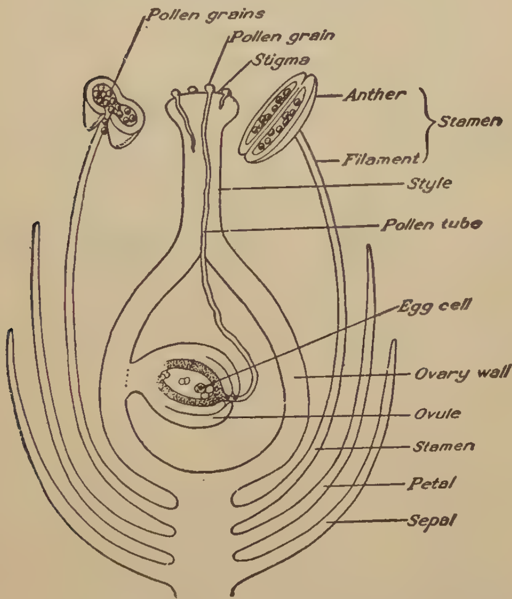
1. A pollen tube grows through the style and reaches an ovule. It then enters the ovule through a tiny opening called the *micropyle* (Fig. 73).

2. One sperm cell nucleus of the pollen tube unites with the egg cell nucleus of the ovule. A *fertilized egg* results.

3. The fertilized egg divides repeatedly, forming an *embryo* or baby plant.

4. The mother plant stores food in the ovule for the nourishment of the baby plant. The baby plant, together with its food supply, is called the *seed.*

5. The pistil develops to form the fruit.



From Biology and Human Welfare *by Peabody and Hunt, The Macmillan Co.*

Fig. 73.—Fertilization of an Egg Cell in an Ovule.

VIII. Fruits.—A fruit is a ripened pistil with any other parts of the flower that may remain attached.

IX. Functions of the Fruit

A. To protect the seeds from drying up.

B. To protect the seeds from insect enemies.

C. To help the dispersal of the seeds.

D. To furnish the seeds with the necessary moisture and mineral matter.

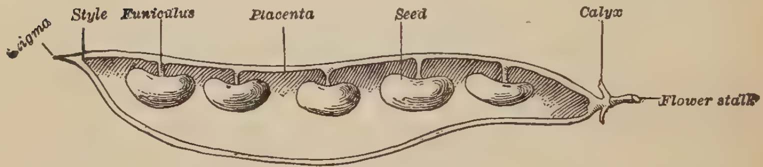


FIG. 74.—THE BEAN POD (INTERNAL VIEW). AN EXAMPLE OF A DRY FRUIT.

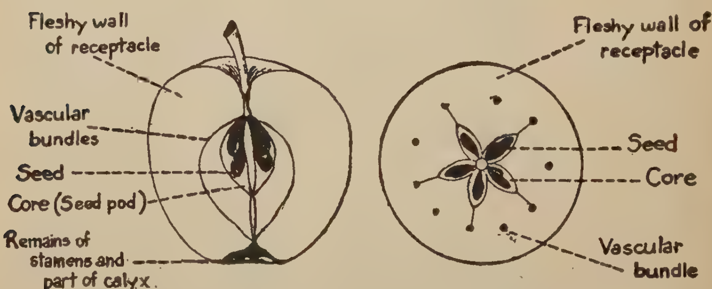


FIG. 75.—THE APPLE (INTERNAL VIEW). AN EXAMPLE OF A FLESHY FRUIT.

X. Reasons for Seed and Fruit Dispersal.—The dispersal of seeds and fruit is necessary to prevent overcrowding.

A. Old plants deprive young plants of sunlight.

B. Old plants have an extensive root system. When water is scarce, young plants, with their undeveloped root system, cannot get a sufficient supply.

C. Old plants can reach deeper into the soil after dissolved mineral matter than young plants.

XI. Seeds.—A seed is a ripened ovule containing an embryo or baby plant together with its food supply and protective coats.

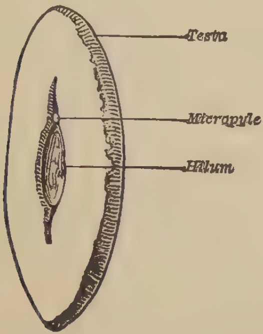


FIG. 76A.—THE BEAN SEED (EXTERNAL VIEW).

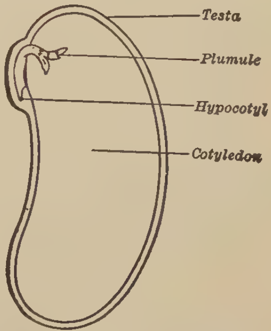


FIG. 76B.—THE BEAN SEED (INTERNAL VIEW).

XII. Parts of a Bean Seed. (Figs. 76A and 76B.)

SEED PART	DESCRIPTION	FUNCTION
Testa	Thick seed-coat.	To protect the inner structures.
Hilum	Oval scar on testa.	Place where the seed was attached to the parent plant.
Micropyle	Minute opening near one end of the hilum, through which the pollen tube entered the ovule.	Takes in water for the seed. Allows the young plant to push through the seed coat.
Cotyledons	Thick seed-leaves.	Generally contain stored food for the baby plant.
Plumule	Small leaflike structures of the seed.	Forms the first true leaves and part of the stem.

Seed Part	Description	Function
Hypocotyl	Stem-like structure of the seed attached to the plumule.	Forms the roots and stem.
Embryo	The baby plant, consisting of the plumule, hypocotyl, and cotyledons.	Develops, under favorable conditions, into a mature plant.

XIII. Germination.—Germination is the sprouting of a seed until it has used up the stored food. When germination is complete, leaves and roots are present, and the young plant can manufacture its own food.

XIV. What conditions are necessary for the germination of seeds? (Experiment)

Condition	Experiment	Observations and Conclusions
Food stored in the seed	Remove the cotyledons from several bean seeds. Place in damp sawdust with other seeds having both cotyledons. Leave in a warm place.	Only those having the cotyledons germinate. Hence *stored food is necessary for germination.*
Air	Pack two bottles with soaked seeds. Cork one bottle. Place both bottles in a warm place.	The seeds in the uncorked bottle germinate; the others do not germinate. Hence *air is necessary for germination.*
Moisture	Place seeds in some sawdust in each of three jars. Dampen the sawdust in one jar, and	The dampened seeds germinate. The dry seeds do not germinate. Those covered with

Condition	Experiment	Observations and Conclusions
	cover the sawdust in the second with water. Keep the sawdust in the third jar dry. Put all three jars in a warm place.	water decay. This shows that *a moderate amount of moisture is necessary for germination.*
Moderate temperature	Place seeds in each of three jars containing moistened sawdust. Keep one jar at room temperature, the second in an ice-box, and the third near a hot oven.	Only those seeds kept in a moderate temperature germinate. Hence *a moderate temperature is necessary for germination.*

XV. Other Experiments with Germinating Seeds

Experiment	Method	Observations and Conclusions
Germinating seeds give off carbon dioxide.	Place some soaked seeds in a flask. In this and another empty flask place vials containing lime water. Cork both flasks and leave in a warm place.	The lime water in the flask containing the germinating seeds turns milky in color, thus proving that *germinating seeds give off carbon dioxide.*
Energy is liberated by germinating seeds.	Place some soaked seeds in a flask. In another flask place some dry seeds of the same kind. Cork both flasks. Insert a thermometer through the cork of each flask so that the bulb rests among the seeds. Leave in a warm place.	The temperature of the seeds becomes higher than that of the surroundings, thus proving that *germinating seeds liberate heat energy.*

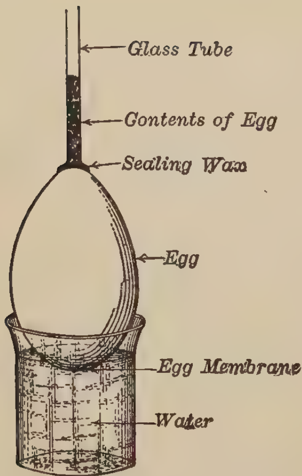


FIG. 77.—EXPERIMENT TO ILLUSTRATE OSMOSIS.

PLANTS AND SOIL WATER

I. Roots.—The chief function of roots is to absorb water and dissolved minerals from the soil by the process of *osmosis.*

II. Osmosis.—Osmosis is the process by which two liquids of *unequal* density, separated by a membrane, tend to pass through the membrane and mingle with each other, the greater flow being towards the denser liquid.

III. To Demonstrate Osmosis. (Key experiment)

PROCEDURE	OBSERVATION
Break through the small end of an egg and insert through the opening a glass tube about 12 in. long. Fasten the tube to the egg with wax. Carefully remove the shell from the lining membrane at the larger end of the egg over an area of about ¾ in. in diameter. Place the egg in a small beaker of water, with the exposed membrane immersed in the water. Examine after about 2 hours.	The contents of the egg rise in the glass tube. The liquid in the egg being denser than the water outside the egg, osmosis takes place; *i.e.,* water passes into the egg through the membrane, thus forcing the contents of the egg into the glass tube.

IV. Root-hairs.—The process of osmosis, by which soil water is absorbed by plants, takes place through the *root-hairs.* These are long, microscopic projections surrounded by a thin membrane and growing out from the surface of the root.

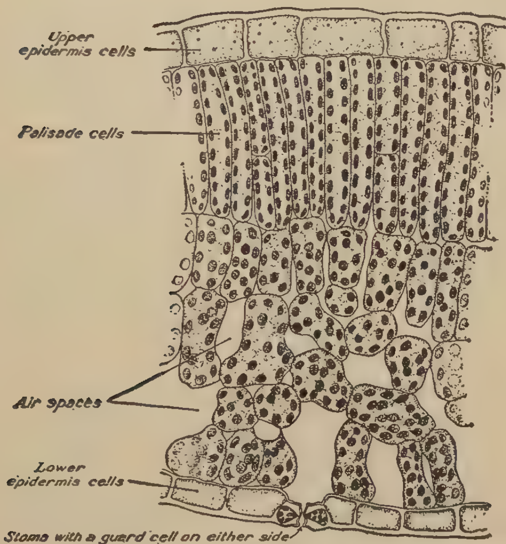
V. What paths do liquids take in the plant stem? (Experiment)

PROCEDURE

Place a stalk of celery in water colored with red ink.

OBSERVATION AND CONCLUSION

The thready portions of the stalk, and the veins in the leaves become red. *Liquids are carried up the stem through the fibrovascular bundles.*



From BIOLOGY AND HUMAN WELFARE *by Peabody and Hunt, The Macmillan Co,*

FIG. 78.—SECTION OF A LEAF.

LEAVES AS GREAT FOOD FACTORIES

I. Functions of Leaves.—Green leaves are the food factories of the plant. Their chief functions are

A. *Photosynthesis*—the manufacture of food for the plant.

B. *Respiration*—the process of taking in oxygen, oxi-

dizing food, and giving off carbon dioxide and other wastes.

C. *Transpiration*—the giving off of excess water by the plant.

II. Microscopic Structure of a Leaf

Part	Description	Function
Epidermis	A layer of thick-walled cells on the outside of the leaf.	Protection.
Palisade cells	Elongated, brick-like cells under the upper epidermis.	Contain chlorophyll bodies.
Parenchyma (*Spongy cells*)	Irregular, loosely connected cells with air spaces between them.	Contain chlorophyll; breathe; digest and assimilate food.
Chlorophyll bodies	Round green masses of protoplasm containing chlorophyll.	Manufacture food for the plant.
Stomata	Slit-like openings enclosed by two kidney-shaped **guard cells.** Generally in the lower epidermis. Open into air spaces.	Regulate the excretion of wastes; admit carbon dioxide for food-making; give off water and oxygen; breathing organs.
Veins	Bundles of *ducts* (tubes) and fibers connecting with the stem.	Stiffen the leaf. Conduct liquids.

III. Photosynthesis.—Photosynthesis is the process by which chlorophyll bodies, aided by sunlight, manufacture starch from carbon dioxide and water. In this process, the energy received from the sun is stored in the starch, and oxygen is released as a by-product.

IV. Experiments on Photosynthesis. (Key experiments)

Experiments	Procedure	Observations and Conclusions
Is sunlight necessary for photosynthesis?	Cover a part of a geranium leaf, which is still attached to the plant, with a strip of black cloth. Leave in the sunlight for a day. Remove the leaf and boil it in alcohol to remove chlorophyll. Test for starch.	Only the part exposed to the sun shows the presence of starch. Hence, *sunlight is necessary for photosynthesis.*
Is chlorophyll necessary for photosynthesis?	Remove a leaf from a plant bearing white and green striped leaves, after it has been in the sunlight. Boil the leaf in alcohol, and test for starch.	Only the part of the leaf that was green shows the presence of starch. Hence, *chlorophyll is necessary for photosynthesis.*
Is carbon dioxide necessary for photosynthesis?	Place a potted plant on a block of wood standing in a pan of lime water[1] so that the pot does not touch the lime water. Cover with a bell jar and leave in the sunlight for two days. Remove a leaf, boil it in alcohol, and test for starch.	No starch is present. Hence, *carbon dioxide is necessary for photosynthesis.*

[1] The lime water removes carbon dioxide.

Experiments	Procedure	Observations and Conclusions
Is oxygen given off during photosynthesis?	Place a water plant under a funnel in a jar of water (Fig. 79). Invert over the funnel a test tube full of water, and leave in the sunlight. Test the gas that has collected in the test tube with a glowing splint the next day.	The splint bursts into flame. Hence *oxygen is given off during photosynthesis.*

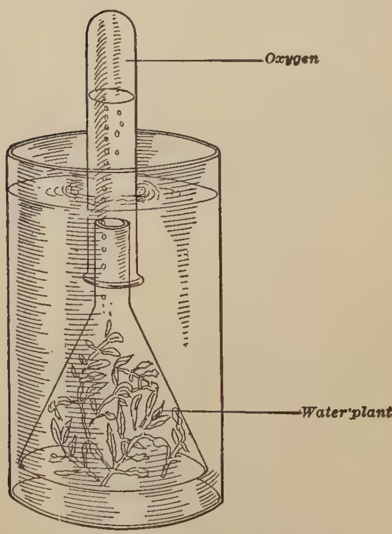


FIG. 79.—EXPERIMENT TO SHOW THAT LEAVES GIVE OFF OXYGEN IN THE SUNLIGHT.

V. Transpiration.—Transpiration is the process by which surplus water passes out from leaves through small pores, called *stomata*, on their under-surface.

VI. Do leaves transpire? (Experiment)

PROCEDURE

Completely enclose the pot and soil of a watered plant with rubber sheeting. Cover with a bell jar and expose to the sun for several hours.

OBSERVATION AND CONCLUSION

Drops of water collect on the inside surface of the bell jar. This water has been given off by the leaves of the plant. Hence, *leaves transpire.*

VII. Do leaves breathe? (Experiment)

PROCEDURE

Place a plant and a shallow dish containing lime water under a bell jar. Let stand for several hours in a dark place.

OBSERVATION AND CONCLUSION

The lime water becomes milky in color. Since this change can be effected only by carbon dioxide, this experiment shows that *leaves breathe; i.e.,* they take in oxygen and give off carbon dioxide.

SOIL AND SOIL FERTILITY

I. Composition of Soil.—Soil is composed of

A. *Organic matter,* formed by the decomposition of the dead bodies of plants and animals. This is the black portion of soil, called *humus.*

B. *Inorganic matter,* formed from

1. The pulverizing of rock by running water, ice, and wind (*erosion*).
2. Oxidation, sudden changes in temperature, and the action of acids (*weathering*).

II. Types of Soil

Type	Description	Remedy
Sandy	Composed of small grains of sand. Does not retain water.	Mix with organic matter.
Clay	Composed of powdered rock. Allows water to penetrate very slowly. Forms mud, which cakes and keeps air out.	Mix with sand and organic matter.
Alkaline	Contains a great amount of alkaline salts. Allows but few plants to grow in it.	Drain and irrigate.
Acid	Has too much acid (formed by the decay of organic matter).	Add lime to neutralize the acid.
Humus	Contains both organic and mineral matter. Supports plant growth.	

III. Rejuvenation of Soil.—The rejuvenation of soil consists in restoring certain elements to it which have been used up, and which are needed for plant growth. These elements are usually nitrogen, potassium, and phosphorus.

IV. Methods Used in Soil Rejuvenation

The addition of—	*Restores*
Stable manure	Nitrogen and potassium.
Guano or bird manure	Nitrogen.
Sodium nitrate	Nitrogen.
Chile saltpeter	Nitrogen and sodium.
Wood ashes	Potassium.
Ground bone or rock phosphate	Calcium and phosphorus.
Gas lime, chipped marble, and gypsum	Calcium.

OTHER METHODS

Method	Restores
Planting clover and plowing the plants under.[1]	Nitrogen.
Fallowing.—Allowing the land to lie idle so that missing substances are restored by oxidation, action of acids, etc.	All needed compounds.
Plowing.—The process of loosening up the soil by turning it over.	Air and moisture.

V. Soil Experiments

Experiment	Method	Observation
What is the composition of soil?	Place a handful of soil in a wide-mouthed bottle about three-fourths full of water. Shake well and allow to stand undisturbed for a few days, or until clear.	The component parts of the soil arrange themselves in layers in the following order: *gravel, sand, clay, humus.*
What is the effect of mulching the soil?	Fill four boxes with soil. In two of these boxes stir the soil to a depth of 2 or 3 inches, and mulch it. Plant seeds in all four boxes, and set aside for several days.	The seeds grow best in the soil that was stirred and mulched, because such soil retains moisture.

1 Small outgrowths on the roots of leguminous plants (clover, beans, peas, alfalfa) contain millions of nitrogen-fixing bacteria which change atmospheric nitrogen into a form which plants can use. A crop which needs much nitrogen (*e.g.*, corn) is planted between two successive clover crops. This method is known as **rotation of crops.**

Experiment	Method	Observation
How does the soil hold water?	1. Place several glass tubes of different diameter upright in a vessel of water.	The water rises highest in the tube having the smallest diameter. This phenomenon is called *capillary action.*
	2. Sprinkle about an inch of finely powdered soil or dust over some soil in a box. Push a finger into the layer of dust. Note where the moisture creeps up more readily.	The dust layer (*mulch*) breaks the capillary tubes and prevents the water from coming to the surface. Where the soil has been packed down, the moisture creeps up readily.

Note.—In dry climates, farmers cultivate the soil after every rain in order to form a mulch. This is referred to as *dry farming.* Gardeners often use straw, leaves, or manure to form a mulch.

INSECTS

I. General Characteristics of Insects

A. The body is divided into three regions: *head, thorax,* and *abdomen.*

B. The body and appendages are jointed.

C. They have three pairs of legs and two pairs of wings.

II. Some Harmful Insects

Insect	Feeds on
Cabbage butterfly	Garden vegetables (cabbages, turnips, etc.).
Potato beetle	Potato plants.

INSECT	FEEDS ON
Tussock moth	Shade trees.
Tent caterpillar	Fruit and shade trees.
San José scale	Fruit trees.
Tree borers	Fruit trees.
Plant lice	Garden plants.

III. Extermination of Harmful Insects

A. *Biting Insects.*—Spray leaves with lead arsenate, Paris green, etc. These substances act as stomach poisons and kill the insects.

B. *Sucking Insects (plant lice and other bugs).*—Spray leaves with water in which tobacco has been soaked.

C. Picking insects by hand. This is done in the case of the potato bug, tomato worm, etc.

D. Encouraging or introducing natural enemies of these insects, such as birds, garden toads, ladybird beetles, etc.

E. Destroying dead leaves and stems to prevent larvae from hibernating over the winter.

FORESTS

I. Economic Importance of Forests

A. Bind the soil together, thus preventing *erosion.*

B. Prevent floods. Dead leaves act like a big sponge.

C. Prevent the drying up of small streams.

D. Regulate and moderate climate.

E. Furnish homes for wild animals, fish, and birds useful to man.

F. Act as windbreaks.

G. Furnish many useful products.

1. Lumber for building construction, furniture, boats, etc.
2. Paper from spruce and poplar.
3. Fuel-wood from most trees: coal.

4. Tar, alcohol, and acetic acid by the destructive distillation of wood.
5. Saps of trees furnish gum, maple sugar, turpentine, rubber, etc.
6. The bark of oak is used for tanning.

II. Causes of Destruction of Forests

A. *Fires* caused by

1. Smoldering camp fires, and careless smokers.
2. Burning over of land for clearing, the fire sometimes getting beyond control.
3. Sparks from passing locomotives.
4. Lightning.

B. *Improper lumbering*

1. Wasteful trimming of lumber.
2. Failure to select older trees.
3. Allowing falling trees to injure young trees.
4. Cutting more trees than are planted.

C. *Miscellaneous causes*

1. Winds, tornadoes, landslides, etc., destroy many trees.
2. Gnawing animals *girdle* and thus kill many trees.

III. Methods of Forest Conservation

A. Reforestation by the government or by individuals.
B. Education of citizens as to the importance of forest conservation.
C. Proper laws and their enforcement.
D. Extension of forest ranger service by the government.
E. Reservation of forest tracts where cutting is either forbidden or is supervised by the government.
F. Elimination of coal-burning locomotives on railroads running through forest regions.

QUESTIONS

1. (a) What is a cell? (b) Make a drawing of a plant cell. (c) Label five parts of this cell, and state the use of each part.

2. *Define:* tissue; organ; chromosome; chlorophyll; nucleus.

3. (a) Name and describe the parts of a typical flower. (b) State the use of each part.

4. With the aid of a labeled diagram, describe the process of fertilization in a flower.

5. (a) Define *pollination.* (b) Describe the various ways in which it may be brought about.

6. (a) What is a fruit? (b) Explain why a pea or bean pod is considered to be a fruit.

7. (a) Name the process by which green leaves make starch. (b) What raw materials are needed in this process? (c) What by-product is given off?

8. Describe an experiment to demonstrate the necessity of light for starch-making.

9. Describe an experiment to prove that plants give off oxygen in the process of starch-making.

10. Describe an experiment to show that water is given off by the leaves of a plant.

11. (a) Define *osmosis.* (b) With the aid of a labeled diagram, describe an experiment to demonstrate osmosis. (c) Show that the three conditions essential for osmosis are present in the materials used.

12. Show how the conditions for osmosis are present in root-hairs.

13. Explain the following statement: "No life could exist on the earth if there were no green plants."

14. (a) What is a seed? (b) Make a drawing of a bean seed, labeling all its parts.

15. (a) What four conditions are necessary for germination? (b) Describe experiments to prove the necessity of these conditions.

16. (a) What two uses do baby plants make of the food supply? (b) Explain the need for each of these uses.

17. Explain what is meant by *rotation of crops.*

18. Describe four methods used in soil fertilization.

19. (a) Name five harmful insects that damage garden crops. (b) Describe the best method of combatting each of these insects.

20. (a) State five ways in which forests are important to mankind. (b) Outline a plan by which forests may be conserved.

21. (a) Describe two methods used for retaining water in the soil. (b) Illustrate one of these methods by means of an experiment.

CHAPTER XIV

THE WORK AND CARE OF THE HUMAN BODY

Systems of the Human Body.—The human body is made up of many organs. These organs are grouped into the following *systems:*

System	Functions
Bony	Forms the framework of the body. Serves for protection.
Muscular	Transmits and uses energy.
Digestive	Changes insoluble foods to a soluble form.
Circulatory	Brings oxygen and digested food to all the cells of the body. Removes carbon dioxide and nitrogenous wastes. Maintains the constant temperature of the body (98.6° F.) Acts as an army of defense against invading germs.
Respiratory	Supplies oxygen to the blood. Removes carbon dioxide resulting from oxidation.
Excretory	Eliminates wastes formed in the body.
Nervous	Coördinates the various systems of the body, making them function harmoniously and efficiently.

FOODS AS FUEL FOR THE HUMAN BODY

I. Foods.—A food is any substance which, when taken into the body, supplies heat and energy, and provides material for the growth and repair of the body tissues.

II. Classification of Foods.—Foods are classified into the following classes, called *nutrients:*

A. Carbohydrates C. Proteins. E. Water.
B. Fats. D. Mineral matter. F. Vitamins.

III. Uses of the Nutrients in the Body

Nutrient	Foods Containing It	Use
Carbohydrates	Bread, cereals, potatoes, raisins, candy.	Furnish heat and energy.
Fats	Butter, milk, bacon, nuts, olive oil.	Furnish heat and energy.
Proteins	Meat, fish, milk, eggs, beans, nuts.	Furnish material for building up and repairing the body tissues. May also furnish energy.
Mineral matter	Vegetables, fruit, milk.	Furnishes material for building bones and teeth. Aids digestion.
Water	Fruits, vegetables, meats.	Helps to dissolve foods and remove wastes. Needed for all life functions.
Vitamins	Fruits, vegetables, milk, cod-liver oil, egg yolk, butter, wheat, ~~milk.~~	Serve as body regulators. Promote growth. Prevent deficiency diseases, such as scurvy and rickets.

IV. Tests for Nutrients. (Key experiment)

Nutrient	Test	Result
Starch	Boil the food in water. Cool, and add iodine solution.	Deep-blue color.
Sugar (*glucose*)	Add water to cover the food, and then add a few drops of *Fehling's solution* or *Benedict's solution.* Heat to boiling.	Orange-red color.
Fat	Heat the food on unglazed paper.	A translucent spot forms on the paper.
Protein	1. Add a few drops of nitric acid to the food. Pour off the acid, wash, and add ammonia.	Yellow color. Turns orange-red when the ammonia is added.
	2. Burn the food and smell.	Odor of burning feathers.
Water	Weigh the food. Leave in a dry, warm place. Weigh again.	Food loses weight.
Mineral matter	Burn the food.	Gray ash remains.

Note.—The presence of vitamins in a food is detected by studying the effects of this food on certain test animals, such as mice, guinea pigs, etc.

V. Vitamins.—Vitamins are certain chemical substances in foods that are essential for health and growth. Their absence in food causes what are known as *deficiency* diseases. The table on page 160 summarizes these diseases and the methods of preventing them.

VITAMIN	DEFICIENCY DISEASES CAUSED BY ITS ABSENCE	METHOD OF PREVENTION	FOODS LACKING THIS VITAMIN
Fat-soluble A	Lack of general health and vigor. *Ophthalmia* or *Xerophthalmia* (dry eyes, blindness, stunted growth).	By the use of animal fats, such as cod liver oil, butter, milk, egg yolk, green vegetables, liver.	White vegetables, lard, and vegetable oils.
Water-soluble B	*Beri-beri* (degeneration of nerve cells and paralysis). *Pellagra* (weakness, nervousness, indigestion).	By the use of natural foods, such as whole grains, yeast, liver, green vegetables.	Denatured foods, such as white flour, white sugar, polished rice, etc.
Water-soluble C	*Scurvy* or "sailor's disease" (sores on skin due to the breaking up of capillaries; general weakness).	By the use of uncooked foods, such as fruits, tomatoes, raw cabbage, leafy vegetables.	Pasteurized milk, and foods cooked slowly in contact with air.
Fat-soluble D[1]	*Rickets* (soft bones, due to lack of calcium or lime).	By the use of cod liver oil, butter, suet. Plenty of sunlight in the open air.	Denatured foods, such as white flour, white sugar, and refined cereals. Most fruits.
Water-soluble E	*Sterility* (inability to produce young).	By the use of green vegetables and the oils from the grains of whole wheat, corn, etc.	White flour, white sugar, polished rice, etc.
F (X or Bios)	*Anaemia.* Growth defects.	By the use of lettuce, yeast, liver.	Denatured foods.

[1] Fat-soluble *D* is not necessary if children have foods containing calcium and phosphorus in their diet, and plenty of sunshine.

VI. Deficient Foods.—Deficient foods are those from which some wholesome part has been removed. The following parts may be absent:

A. *Cellulose*—woody material necessary for the proper stimulation of the digestive tract.

B. *Mineral matter*—needed for the building of bone tissue.

C. *Vitamins*—necessary for good health.

> **Examples.**—White flour, polished rice, boiled foods, refined cereals.

VII. Fuel Value of Nutrients.—The fuel value of a food is measured in terms of *calories*. A *large calorie* is the amount of heat required to raise the temperature of one kilogram of water one degree Centigrade. This is equivalent to raising the temperature of one pound of water four degrees Fahrenheit.

> **Examples.**—A pound of starch, sugar, or protein yields about 1800 calories. A pound of fat yields about 3600 calories.

VIII. Factors Affecting Diet

FACTOR	EFFECT ON DIET
Occupation	A person who does strenuous physical work requires an increased amount of food. A person who does light physical work, or is engaged in a sedentary occupation, requires less food.
Climate	People in cold climates require heat-producing foods such as fats. People in warm climates eat vegetable foods which consist chiefly of water.
Age	Young people require more food than older people, who no longer need ma-

Factor	Effect on Diet
	terial for growth and are not as active.
Sex	Boys and men require more food than girls and women because they do more strenuous physical work.
Health	A person who is in good health requires more food than one who is in ill health.
Person himself	Each person has his own peculiarities. A food which is beneficial to one person may be harmful to another.

IX. Kinds of Diets

Diet	Value of This Diet
Meat	Protein is used for growth; it may be oxidized for fuel. When taken in excess, it leaves much waste which overburdens the kidneys.
Canned food	May result in a deficiency of one of the vitamins necessary for proper nutrition.
Vegetable	Reduces the danger of eating too much protein. Cellulose of plant cells stimulates elimination.
Balanced	Consists of a proper proportion of meats and vegetables. The proportion should be: 1 part of protein, 3 parts of fat, and 6 parts of carbohydrates. (*Professor Chittenden.*)

X. Milk.—The following analysis of a gallon of milk shows why it is a perfect food.

Substance	Amount Present	Use
Water	About 3 quarts.	Contains water-soluble vitamin *B*.
Butter fat	About 5.2 ounces.	Supplies heat and energy. Contains an abundance of fat-soluble vitamin *A*.
Milk sugar	About 6.8 ounces.	Supplies heat and energy.

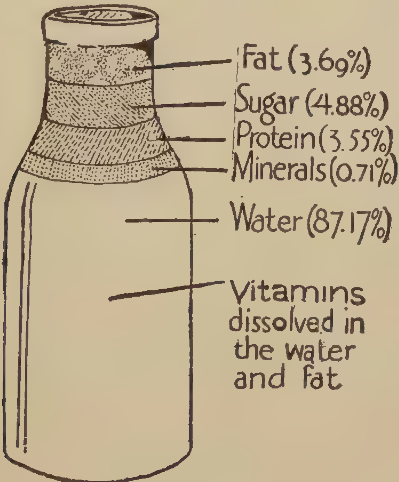


Fig. 80.—Composition of Milk.

Casein	About 4.9 ounces.	Best protein for the building of tissue.
Lime (*calcium*)	70 grains.	For building bones and teeth. Helps to clot the blood and to fight the germs of tuberculosis.
Iron	0.5 grain.	Helps make red corpuscles of the blood.
Phosphorus, potassium, and other minerals	About 166 grains.	Regulate the functions of the different organs of the body.

XI. Cooking of Foods.—Foods are cooked in order to

A. Destroy parasites and disease germs.
B. Render the food more palatable and more digestible.

XII. Methods of Cooking

A. *Broiling* forms a hard crust on the outside of meats, thus preventing the escape of juices. It is the best method of preparing steaks and chops.
B. *Frying* coats food with a layer of fat, which may interfere with digestion.
C. *Baking* retains mineral matter and improves the flavor. It is a good method of cooking potatoes, squash, etc.
D. *Steaming* is the best method of cooking most vegetables. Valuable mineral matter, which would be lost by boiling, is retained.
E. *Roasting* acts on food much like broiling. It is the best method of cooking most meats.
F. *Boiling* is, as a rule, objectionable because it causes much valuable mineral matter to be lost.

XIII. Adulteration of Foods.—An adulterant is a substance which is used to replace a more expensive part of some food, with the intention to defraud.

Examples

1. Glucose for cane sugar (*not harmful*).
2. Sawdust or bran for flour (*harmful*).
3. Alum to make flour whiter (*harmful*).
4. Water for milk (*not harmful*).
5. Cottonseed oil for olive oil (*not harmful*).
6. Chicory for coffee (*not harmful*).
7. Oleomargerine for butter (*not harmful*).

XIV. Tests for Some Common Adulterants

Adulterant	Test	Observations
Chicory in coffee	Place a teaspoonful of ground coffee on the surface of water in a glass. Allow to stand for about five minutes.	If the material floats, it is pure coffee. If some of it sinks, chicory is present.
Formaldehyde in milk	Add to a sample of the milk a little hydrochloric acid and a drop of ferric chloride. Stir, and warm for five minutes in hot water.	If a lavender color is produced, formaldehyde is present.
Oleomargarine in butter	Put a sample of the butter in a spoon and melt it over a flame.	If strong sputtering results, the butter has been adulterated with oleomargarine.
Starch in sugar	Add a few drops of iodine to a sample of the sugar.	If starch is present, a deep-blue or black coloration results.

THE DIGESTION OF FOODS

I. Digestion.—Digestion is the process by which food is rendered soluble so that it can be absorbed by the blood and used by the body. Digestion may be

A. *Mechanical*

1. The mixing of saliva with food by the teeth and tongue.
2. The breaking up of food by the teeth.
3. The churning of food by the stomach.

B. *Chemical.*—The action of *enzymes* on the various nutrients, which changes them into a soluble form.

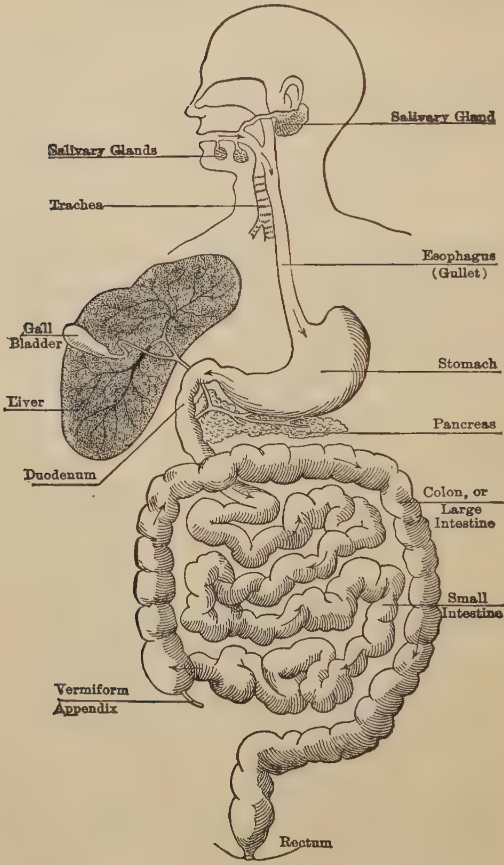


FIG. 81.—DIAGRAM OF THE DIGESTIVE SYSTEM OF MAN.

II. The Digestive Organs and Their Functions

ORGAN	SECRETION AND ENZYMES	FUNCTIONS
Mouth	*Saliva,* containing the enzyme *ptyalin.*	Breaks up and softens the food. Changes starch to sugar.

Organ	Secretion and Enzymes	Functions
Stomach	*Gastric juice,* containing hydrochloric acid, pepsin, and rennin.	Churns the food. Pepsin digests protein. Absorbs some digested food.
Liver	Discharges *bile* into the small intestine. Contains no enzymes.	Stores sugar in the form of glycogen. *Bile* helps to absorb fats, and acts as an antiseptic in the intestine.
Pancreas	Pours *pancreatic juice* into the small intestine. Contains the enzymes *trypsin, amylase,* and *lipase.*	*Trypsin* digests protein; *amylase* digests starch; *lipase* digests fats.
Small intestine	*Intestinal juice,* containing *erypsin* and *invertase.*	Completes the digestion of protein, starch, and fat. Absorbs digested food into the blood.
Large intestine	Does not secrete digestive juices.	Absorbs some digested food and water from wastes. May also absorb some poisonous products of decay.

III. How is starch digested in the mouth? (Key experiment)

Procedure	Observations and Conclusions
Make a thin starch paste. Test with Fehling's solution.	The color of the mixture does not turn brick-red, showing that sugar is not present.
Test some saliva with Fehling's solution.	The same negative result as above.
Mix some starch paste and saliva in a test tube. Place the test tube in a beaker of warm water, and set aside for 10 minutes. Test with Fehling's solution.	The mixture of starch and saliva assumes a brick-red color, showing that sugar is present. The saliva has digested the starch.

IV. Hygiene of Digestion

A. Avoid overeating. Leave the table while still slightly hungry.

B. Eat daily some hard, some bulky, and some raw food.

C. Eat sparingly of meats and eggs.

D. Eat slowly and chew well. The food is thus mixed thoroughly with saliva.

E. Avoid eating between meals.

F. Avoid unpleasant emotions at meal times, because they interfere with proper digestion.

G. Avoid the excessive use of sweets, sodas, etc., because they dull the appetite and overburden the digestive system.

H. Exercise moderately every day. Moderate exercise promotes digestion.

V. Structure of a Tooth

Part	Location	Use
Crown	Part projecting from the gum.	For biting.
Fang	Part imbedded in the jaw-bone.	Acts as an anchorage for the tooth.
Pulp cavity	Cavity in the center of the tooth.	Contains nerves and blood vessels.
Dentine	A hard, limy substance around the pulp cavity.	Forms the body of the tooth.
Enamel	A very hard substance around the dentine on the crown.	Protects the tooth from decay.

Cement	A thin layer of bony material around the root of the tooth.	Cements the tooth to the jaw-bone.

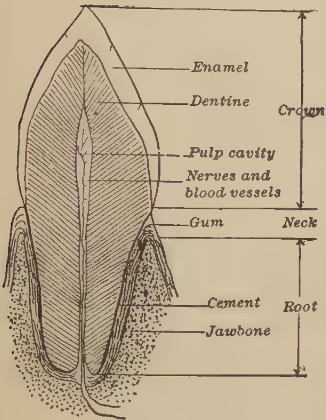


Fig. 82.—Section of a Tooth.

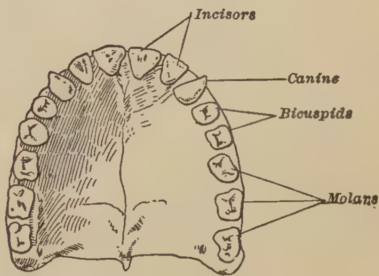


Fig. 83.—Arrangement of the Teeth in the Upper Jaw.

VI. Care of the Teeth

A. Brush your teeth in the morning and at night with a good stiff brush.

B. Use a tooth paste or powder recommended by a reliable dentist. Castile soap or precipitated chalk may be used.

C. Have your teeth examined by a competent dentist at least once every six months. He will remove accumulated *tartar*, which shelters germs of decay.

D. Use dental floss to remove food particles from between the teeth.

E. Do not bite hard objects with your teeth.

F. Temporary teeth should not be neglected.

Note.—For structure and care of the ears, see pages 76–77. For structure and care of the eyes, see pages 105 and 108.

HOW DIGESTED FOODS ARE CARRIED TO THE CELLS

I. The Circulatory System.—The functions of the circulatory system are

A. To carry oxygen and digested food to all the cells of the body.
B. To remove carbon dioxide and nitrogenous wastes.
C. To maintain the constant temperature of the body (98.6° F.).
D. To destroy germs and their excretions.

II. Parts of the Circulatory System

Part	Description	Function
Heart	Muscular, conical-shaped organ, about the size of a man's fist. It is situated in the middle of the chest cavity.	Pumps the blood around the body.
Auricles	Thin-walled upper two chambers of the heart.	Receive the blood from the veins and send it down to the ventricles.
Ventricles	Muscular lower two chambers of the heart.	Pump the blood into the arteries.
Arteries	Thick-walled, muscular, elastic blood vessels.	Carry blood from the heart to all parts of the body.
Veins	Thin-walled, inelastic blood vessels.	Carry blood from all parts of the body back to the heart.
Capillaries	Microscopic, thin-walled blood vessels. Connect the veins with the arteries.	The thin walls permit the exchange of liquids and gases by osmosis.

Part	Description	Function
Blood	A red fluid, containing *corpuscles* and *plasma*. Makes up one-twelfth of the weight of the body.	Carries food and oxygen to all parts of the body, and removes waste.
Red corpuscles	Microscopic, disc-shaped, red cells, containing *haemoglobin.*	Carry oxygen.
White corpuscles (*Phagocytes*)	Colorless, amoeboid cells, larger than red corpuscles. Can pass through walls of blood vessels.	Destroy bacteria that gain entrance into the body.
Plasma	Creamy-colored liquid of the blood. Contains protein substance (*fibrinogen*) and immunizing agents.	Carries digested food and wastes. *Fibrinogen* causes blood to clot.
Lymph	A clear liquid, similar to plasma. Oozes through the walls of the capillaries, and flows around the cells.	Acts as a medium of exchange between the blood and the cells.

III. Hygiene of the Circulatory System

A. Moderate exercise aids circulation, and the elimination of wastes. It also helps keep the muscles toned up.

B. Slight bruises or cuts should be washed with a dilute solution of iodine or *zonite.*

C. When an artery is cut, put a compress on the wound until the blood clots. If this fails, place a bandage (*tourniquet*) on the limb, *between* the cut and the heart, and twist it with a stick. Do not remove the tourniquet until the blood clots.

D. When a vein is cut, apply a compress until the blood clots. If this fails, place a *tourniquet* on the limb, on the side of the wound *away* from the heart. Wash with boric acid and bandage with a clean cloth.

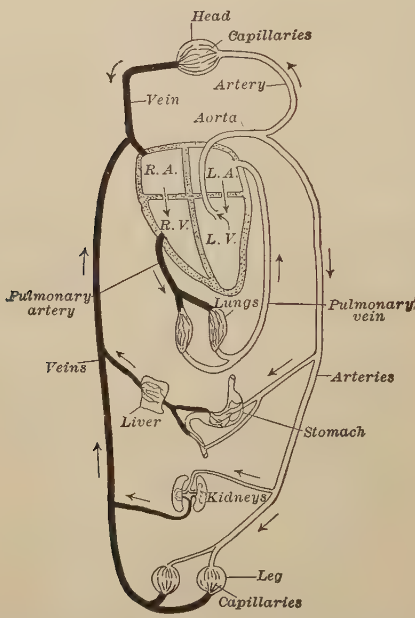


FIG. 84.—DIAGRAM SHOWING THE COURSE OF THE BLOOD IN THE HUMAN BODY.

THE BREATHING ORGANS OF THE HUMAN BODY

I. The Respiratory System.—The functions of the respiratory system are

A. To supply oxygen to the various tissues of the body.

B. To remove carbon dioxide resulting from oxidation.

II. Parts of the Respiratory System and Their Functions

A. *Nose.*—The mucus moistens the air. The small hairs filter out dust. The rich supply of blood in the blood vessels warms the air.

B. *Trachea.*—A long cartilaginous tube, leading from the throat to the bronchial tubes. Carries air to the bronchial tubes.

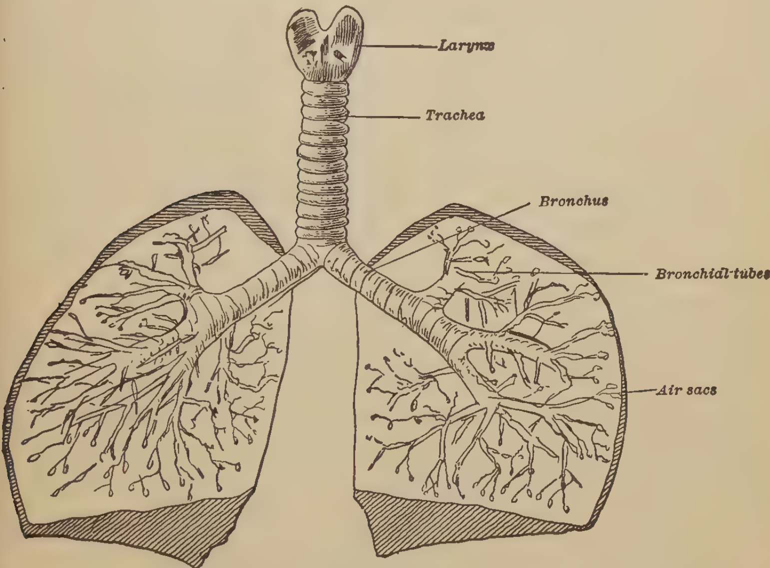


FIG. 85.—THE LUNGS.

C. *Bronchial tubes.*—Two big branches of the trachea leading to the lungs. Carry air to the lungs.

D. *Lungs.*—Two large spongy sacs in the chest cavity. Contain a rich supply of blood. Supply oxygen to the blood and remove carbon dioxide and water from it.

E. *Diaphragm.*—A muscular partition separating the heart and lungs from the other organs of the body cavity. The alternate expansion and contraction of the diaphragm helps to fill and empty the lungs.

III. Artificial Respiration.—Artificial respiration is resorted to when normal respiration has ceased. The *Shaefer Method* for inducing respiration artificially is as follows:

A. Place the victim face down, with his head resting on one arm.

B. Sit astride the patient, and place a hand on each side of his body, with the fingers on the ribs.

C. Exert pressure for a few seconds downward and inward, relax the pressure for a few seconds, and repeat at the rate of fifteen times a minute until normal respiration is restored.

D. When the patient regains consciousness, administer a stimulant.

IV. Hygiene of Respiration

A. Moderate exercise enlarges the chest cavity and strengthens the lower portion of the lungs.

B. Ventilate all rooms, so that the temperature is kept at about 68° F. and the humidity at about 55%.

C. Wear light, loose, porous clothing.

D. If possible, sleep outdoors.

E. Spend at least two hours a day outdoors.

F. Breathe deeply. Deep breathing exercises the lungs and helps remove much waste.

HOW THE HUMAN BODY GETS RID OF WASTES

I. Function of the Excretory System.—The function of the excretory system is to eliminate wastes formed in the body. Failure to eliminate these wastes results in *auto-intoxication* or self poisoning, which may eventually cause death.

II. Nature of Wastes Formed in the Body

WASTES	ELIMINATED BY
Water	Lungs, kidneys, and skin.
Nitrogenous wastes	Skin and kidneys.
Carbon dioxide	Lungs.
Undigested food	Rectum.

III. Hygiene of Excretion

A. The bowels should be evacuated regularly and completely at least once a day.

B. Drink at least six glasses of water a day, to dissolve and help eliminate wastes.

C. Cleanse the exposed parts of the skin with soap and water before each meal.

D. Bathe frequently. Warm baths should be taken at night; cold baths, in the morning.

1. *Warm baths* bring blood close to the surface of the body and induce sleep. Care should be taken not to chill the skin too suddenly after a warm bath. The congestion of blood which occurs may result in a cold.

2. *Cold baths* send the blood inward, and are invigorating and stimulating to most people. They should be avoided, however, if they cause any depressing or weakening effects.

HOW THE WORK OF THE HUMAN BODY IS CONTROLLED

I. The Nervous System.—The function of the nervous system is to coördinate the various parts of the body and make them work harmoniously and efficiently.

II. Parts of the Nervous System

Part	Description and Function
Brain	A large, convoluted, soft mass inside of the skull. Composed of the *cerebrum*, *cerebellum*, and *medulla*. Chief regulating part of the nervous system.
Cerebrum (*Forebrain*)	The largest part of the brain, occupying the front and almost the entire cavity of the skull. Controls thought and voluntary actions.
Cerebellum	Located under, and in back of, the cerebrum. Controls balancing, the coördination of the body, and habits.
Medulla	Connects the brain with the spinal cord. Regulates the working of the vital organs, breathing, circulation, etc.
Spinal cord	A long white cord enclosed in the spinal column. Controls *reflex actions*.
Sympathetic nervous system	Two chains of nerve ganglia, one on each side of the spinal cord. Controls the organs over which we have no voluntary control, such as the stomach, etc.
Nerves	Long white cords connecting the brain and spinal cord with the organs of the body. Those that carry messages from the organs of the body to the spinal cord and brain are called *afferent nerves*. Those that carry messages from the brain and spinal cord to the organs of the body are called *efferent nerves*.
Neurons	Irregular cells having a nucleus near the center, and long branching nerve fibers projecting from them. They receive and send messages.

III. Movements Controlled by the Nervous System

A. *Voluntary Movements.* — Movements purposely made and under the control of the will.

B. *Reflexes.*—Movements which are not controlled by the will or the brain.

> **Example.**—A person draws his hand away from a hot object before he feels the pain.

C. *Habits (Acquired Reflexes).*—Habits are reflexes developed by long practice.

> **Examples.**—Walking, talking, athletic skill.

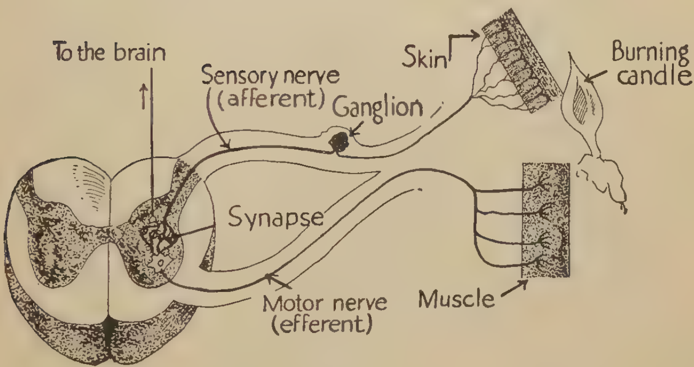


Fig. 86.—A Simple Reflex Arc.

IV. Stimulants and Narcotics

A. *Stimulant.*—A stimulant is a substance which, when taken into the body, temporarily increases the activity of the nervous system.

> **Examples.**—Tea, coffee, alcohol.

B. *Narcotic.*—A narcotic is a substance which, when taken into the body, decreases the activity of the nervous system. It induces sleep or partial or com-

plete unconsciousness. Large doses may cause death.

Examples.—Cocaine, morphine, opium, tobacco, alcohol in excess.

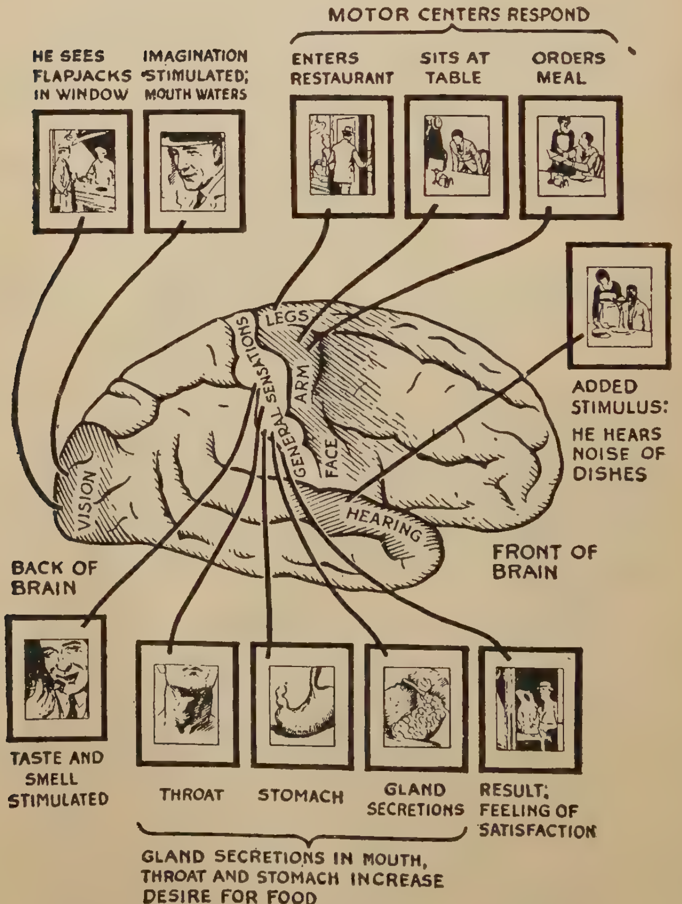


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FIG. 87.—HOW THE BRAIN CONTROLS THE BODY.

V. What is the effect of alcohol on digestion? (Demonstration)

PROCEDURE	OBSERVATION AND CONCLUSION
Place a small quantity of the white of a raw egg (*protein*) in a test tube. Add alcohol.	The white of egg is coagulated. When coagulation takes place in the stomach, the protein is rendered less digestible.

VI. Effect of Alcohol on the Body.—Very small quantities of alcohol act as a stimulant. The general effect is that of a narcotic. The following table summarizes the effect of alcohol on the body as a whole and on the various body systems.

PART AFFECTED	RESULTS
Entire Body	Stunts growth. Lowers resistance to disease. Decreases bodily activity.
Digestive System	Irritates the liver. Causes indigestion.
Circulatory System	Weakens the white blood corpuscles. Weakens the action of the heart. Hardens the arteries.
Respiratory System	Lowers resistance to such diseases as pneumonia, tuberculosis, etc.
Excretory System	Irritates the kidneys. May cause Bright's disease.
Nervous System	Destroys the will power and paralyzes the higher nerve centers. May cause unconsciousness and death.

VII. Effect of Tobacco on the Body

A. Destroys red blood corpuscles.
B. Weakens the heart and unsteadies the nerves.
C. In young people it stunts growth, shortens the wind, and affects the action of the heart.
D. Destroys will power. Causes a craving for more.

VIII. Patent Medicines

A. *Basis.*—Most patent medicines contain large quantities of alcohol, opium, morphine or cocaine.

B. *Dangers*

1. Most patent medicines are habit forming.
2. Some are heart depressants; *i.e.*, they slow up the heart because they contain *acetanilid.*
3. Instead of helping, they aggravate disease.
4. May cause death.

C. *Remedy.*—The Pure Food and Drugs Act requires that a statement of the contents of patent medicines be printed on the label. People should read these labels.

IMPORTANCE AND SOURCES OF CLOTHING

I. Clothes and Health.—Clothing is a hygienic necessity. To be hygienic, clothing should be porous. The chief uses of clothing are

A. To protect the body from mechanical injury.
B. To regulate the body temperature when one passes from a warm to a cold place.

II. Characteristics of Some Clothing Materials

A. *Wool* is a hair fiber obtained from the coat of such animals as the sheep, angora goat, camel, and llama. When burned, it has a disagreeable odor and leaves a char.

B. *Silk.*—Real silk consists of the filaments spun by the silk worm for its cocoon. The fiber is round and smooth and has a beautiful luster. It burns like wool.

C. *Cotton* is a vegetable fiber obtained from the cotton plant. It burns rapidly, with little odor.

D. *Linen* is made from the flax plant. It is stronger than cotton.

E. *Rayon* (artificial silk) is made from cotton by chemical treatment. It has a silky luster.

F. *Rubber* is made from the *latex* or milk of the rubber tree.

G. *Furs* are the skins of certain animals. Their efficiency depends upon the fact that the spaces between the fine hairs contain air, which is a nonconductor of heat.

QUESTIONS

1. Make a labeled drawing of the principal parts of the alimentary canal.

2. (a) Why must starchy foods be digested? (b) What enzyme in the saliva digests starch? (c) Describe an experiment to prove that this enzyme digests starch.

3. (a) Discuss the structure of human blood. (b) Give the uses of the red corpuscles; the white corpuscles; the plasma.

4. (a) Discuss the different kinds of diet. (b) What is the value of each?

5. Describe the best method of balancing the diet.

6. Discuss the hygiene of digestion.

7. What should be done in the case of a severed artery between the elbow and the wrist? Give reasons for your answer.

8. What should be done in the case of a severed vein between the elbow and the shoulder? Give reasons for your answer.

9. (a) Describe the method of reviving a person who is unconscious from apparent drowning. (b) State the purpose of each step in the method described.

10. What is the function of the respiratory system?

11. Describe experiments to identify the nature of the wastes given off in respiration.

12. (a) Explain why rooms should be ventilated. (b) Describe the best method of ventilating a room.

13. What are the functions of the nervous system?

14. Trace the relation of the nervous system to the acquiring of habits.

15. Define *stimulant*. Give three examples.

16. Define *narcotic*. Give three examples.

17. Describe the effects of alcohol on (a) the body as a whole; (b) the nervous system.

18. State four effects of tobacco on the body.

19. Summarize the rules of hygiene.

20. (a) Discuss the characteristics of the various fibers used in making clothing. (b) State the purpose for which each is best adapted.

CHAPTER XV

MICROÖRGANISMS AND THEIR WORK

I. Microörganisms.—Microörganisms are the smallest living things of which we have any knowledge. There are two classes:

A. Plant microörganisms, such as bacteria, yeasts, and molds.

B. Animal microörganisms, such as the amoeba or paramecium (*protozoa*).

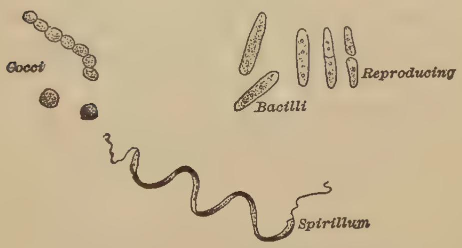


FIG. 88.—FORMS OF BACTERIA.

II. Bacteria.—Bacteria are the smallest and simplest forms of plant life known. The average bacterium measures from 1/25,000 to 3/25,000 of an inch in diameter and about 1/5000 of an inch in length.

III. Forms of Bacteria.—There are three well-defined forms of bacteria: the sphere (*coccus*), the rod (*bacillus*), and the spiral (*spirillum*).

IV. Reproduction of Bacteria.—A bacterium grows to a certain maximum size and then divides into two equal parts by simple division (*fission*). Under favorable conditions, fission takes place once every twenty to thirty minutes.

V. Spore Formation.—Under certain unfavorable conditions, bacteria form spherical *spores* having a tough outer covering. The spores tide the bacteria over periods of famine, dryness, and unsuitable temperature. When favorable conditions are restored, growth and reproduction again become normal.

VI. Method Used in Studying Bacteria

A. Agar is dissolved in boiling water.
B. While still hot, it is poured into a Petri dish.
C. The dish is then sterilized by heating in a steam sterilizer. Resistant spores are thus kilied.
D. The sterilized dish is then exposed to the substance being tested for bacteria, such as dirt, hair, mucus, etc.
E. The agar is then *incubated* (kept in a warm place). If bacteria are present, they multiply and form *colonies* which are visible to the naked eye.

VII. How do conditions of environment affect the development of bacteria? (Key experiments)

Experiment	Procedure	Observations and Conclusions
What is the effect of cold on bacteria?	Place bacteria in each of two sterile Petri dishes containing a culture medium. Keep one dish on ice and the other in a warm place for several days.	Bacteria do not develop in the dish placed on ice. Many colonies develop in the second dish. Hence, *cold is unfavorable to the growth of bacteria.*

Experiment	Procedure	Observations and Conclusions
What is the effect of heat on bacteria?	Place bacteria in each of two sterile Petri dishes containing a culture medium. Expose one dish to a high temperature for about an hour. Keep both dishes in a warm place for several days.	Bacteria do not develop in the dish exposed to a high temperature. Many colonies develop in the second dish. Hence, *extreme heat kills bacteria.*
What is the effect of dryness on bacteria?	Place a dry and a wet piece of meat in a warm place for several days.	The dry meat does not change. The wet meat decays. Hence, *dryness is unfavorable to the growth of bacteria.*
What is the effect of sunlight on bacteria?	Place bacteria in each of two sterile Petri dishes containing a culture medium. Cover one dish with a cardboard. Expose both dishes to sunlight for several hours.	Bacteria develop in the covered dish; none develop in the other dish. Hence, *sunlight kills bacteria.*

VIII. Bacteria, Yeasts, and Molds. (Key experiments)

Experiment	Procedure	Observations and Conclusions
What is the effect of bacteria on food?	Place a small piece of meat in a shallow dish containing a little water. Cover the dish and keep it in a warm place for a few days.	The appearance and odor of the meat show that decay has taken place. Bacteria of decay exist everywhere, and cause protein food to decay or *putrefy*.

Experiment	Procedure	Observations and Conclusions
What is the effect of yeast on sweet juices?	Place a small piece of yeast cake in a glass containing sweet fruit juice. Leave the dish in a warm place for a day. Note the odor. Bubble some of the escaping gas through clear lime water.	Odor of alcohol. The lime water becomes milky in color. This shows that the yeast changed the sugar in the fruit juice to alcohol and carbon dioxide. This process is called *fermentation.*
What is the action of yeast in bread-making?	Add a piece of yeast to sweet fruit juice or molasses. Prepare some dough and mix the yeast preparation with part of it. Leave both pieces of dough in a warm place for several hours.	The dough to which the yeast has been added "rises." The little holes which appear in this dough are formed by the escaping carbon dioxide gas. The other piece of dough remains unchanged.
What is the action of the bread mold?	Moisten a piece of bread, place it in a saucer, and allow to stand for about an hour. Invert a glass tumbler over the bread and keep in a warm place for several days.	The bread becomes dark and mushy in spots. *Molds destroy starchy foods.*

IX. Food of Microörganisms.—Since bacteria, yeasts, and molds do not contain chlorophyll, they cannot manufacture their own food, but must obtain it from living or dead organic matter. These organisms are classed as either *parasites* or *saprophytes.*

A. *Parasites.*—A parasite is a plant or an animal that lives in or on living bodies from which it obtains its food.

Examples.—T a p e w o r m; disease-producing bacteria.

B. *Saprophytes.*—A saprophyte is an organism that lives on dead organic matter.

Examples.—Molds, mushrooms, yeasts, bacteria of decay.

X. Preservation of Food.—The following methods are used to prevent the spoiling of foods by microörganisms:

A. *Pasteurization.*—Milk is heated at a temperature of 160° F. for about 20 minutes. The heat kills most of the microörganisms.

B. *Canning.*—The food is boiled before it is placed in the can. The can is then sealed to prevent the entrance of live germs.

C. *Drying.*—Germs cannot live in the absence of moisture.

D. *Refrigeration.*—The food is cooled to a temperature at which germs cannot grow

E. *Preservatives.*—The presence of substances like salt, sugar, vinegar, spices, benzoate of soda, etc., prevents the growth of germs.

XI. How Milk is Pasteurized. (Key demonstration)

Procedure	Observation and Conclusion
Sterilize two bottles by boiling in water for about 15 minutes. Fill both bottles with fresh milk. Place one bottle in a kettle of water, cover, and heat for about 30 minutes at a temperature of 160° F. Place both bottles in a warm place. Note the odor and taste of the milk in each bottle after one day and after two days.	Although in time the milk in both bottles sours, the pasteurized milk remains sweet for a longer period than the milk in the other bottle. Hence pasteurization helps to preserve milk.

XII. How Germs Enter the Body.—Disease-producing germs may enter the body through

A. The nose and mouth (with air, water, and food).
B. The eyes (with dust and dirt).
C. The skin (when broken or cut).

XIII. The Prevention of Disease

Disease	Method of Infection	Method of Prevention
Blood poisoning (tetanus)	Through cuts in the skin, and wounds caused by fireworks.	Wash the wound with a disinfectant and bandage to prevent reinfection. Injection of serum is sometimes necessary.
Colds, influenza, and pneumonia	Entrance of bacteria through the nose and mouth. Spread by coughing, sneezing, and spitting.	Keep away from crowds. Keep in good physical condition. Avoid dissipation.
Diphtheria	By contact with an infected person. By using dishes in common with an infected person.	Quarantine the sick. **Schick test** and toxin-antitoxin treatment.
Malaria	Through the bite of the *Anopheles* mosquito.	Destroy the mosquitoes and their breeding places.
Typhoid	Through milk, water, oysters, and uncooked vegetables. Through "typhoid carriers."	Pasteurize or boil liquid foods. Cook other foods. Thoroughly wash uncooked foods. Examine the health of cooks.

Disease	Method of Infection	Method of Prevention
Tuberculosis	Eating the meat or drinking the milk of tubercular cows. Spread by kissing, sneezing, coughing, spitting, and using eating utensils in common with a tubercular patient.	Avoid crowds. Wholesome food, sanitation, moderate exercise, sunlight, fresh air, and optimism.
Yellow fever	Through the bite of the *Aëdes* mosquito.	Destroy the mosquitoes and their breeding places.

XIV. How to Destroy Germs.—Disease-producing germs may be destroyed by

A. Burning.
B. Fumigation.
C. Boiling.
D. *Antiseptics,* such as solutions of salt or boric acid, and extremely weak solutions of iodine, bichloride of mercury, hydrogen peroxide, etc.
E. *Disinfectants,* such as carbolic acid, formalin, lysol, etc.

XV. How the Body Fights Germ Diseases.—The body has three lines of defense against invading germs:

A. *Skin.*—The skin is impervious to bacteria.
B. *White Blood Corpuscles.*—These corpuscles destroy germs by eating them.
C. *Antitoxins or Antibodies.*—The blood produces antitoxins, which counteract the poison (*toxins*) produced by disease germs.

XVI. Immunity.—A person may become immune to such diseases as diphtheria, smallpox, scarlet fever, typhoid, etc., if his blood produces enough antitoxin to counteract the effects of the toxins. Immunity may be either *natural* or *acquired.*

A. *Natural immunity* is either inherited or is secured by recovering from certain diseases which leave antitoxins in the blood.

B. *Acquired* or *artificial immunity* may be secured by injecting into the blood of a person antitoxins or serums produced in the bodies of other animals. Weakened parasites (*vaccines*) are sometimes injected into the blood to stimulate the formation of antitoxins, as in smallpox.

XVII. Beneficial Germs

A. *Nitrogen-fixing bacteria* combine atmospheric nitrogen with minerals in the soil, thus forming soluble nitrates and other compounds which plants can use.

B. *Bacteria of decay* may act either beneficially or harmfully.

1. *Beneficially,* by decomposing organic matter and returning it to the soil in the form of soluble compounds which plants use in manufacturing food. They also impart flavors to meats and cheese.
2. *Harmfully,* by destroying our food and clothing. They sometimes form *ptomaines* in foods, especially in canned fish and meats. Ptomaine poisoning may cause serious illness and sometimes death.

C. *Lactic acid bacteria* cause milk to sour. *Acetic acid bacteria* aid in making vinegar.

D. Certain bacteria aid in the tanning of leather, in the preparation of flax for linen, in the curing of tobacco, and in other useful processes.

QUESTIONS

1. (a) What are bacteria? (b) How do they reproduce?

2. Describe a laboratory experiment showing what conditions are favorable to the growth and development of bacteria.

3. Mention five ways of killing harmful bacteria.

4. Describe five ways of preserving foods.

5. (a) How are foods canned? (b) How is milk pasteurized?

6. Explain why yeast is used in bread-making.

7. Discuss the method of infection and prevention of each of the following diseases: (a) blood poisoning; (b) colds; (c) typhoid.

8. Discuss the three lines of bodily defense against disease-producing germs.

9. *Define*: natural immunity; antitoxin; quarantine; inoculation; fumigation; toxin; vaccine.

10. Name the principal infectious diseases that may be acquired from (a) water; (b) milk; (c) dust.

11. Explain how bacteria of decay may be both useful and harmful.

12. (a) What are nitrogen-fixing bacteria? (b) Discuss their importance.

CHAPTER XVI

THE SUN AS THE SOURCE OF ALL ENERGY

I. The Sun as an Engine.—The sun is an enormous engine that runs the earth and the rest of the solar system. Its radiant energy may be converted into other forms of energy, such as heat, mechanical energy, and chemical energy.

II. How the Sun's Radiant Energy Is Converted into Other Forms of Energy. (Experiments)

Kind of Energy	Procedure	Observations and Conclusions
Heat energy	Blacken the outside surface of a test tube with the soot from a candle flame, and fill the test tube three-fourths full of water. Place this test tube in a rack, alongside of a clean test tube full of water. Note the temperature of the water in each, and place both tubes in direct sunlight. Note the temperature of the water in both tubes twenty minutes later.	After exposure to direct sunlight, the water in the blackened test tube is found to be warmer than that in the other test tube. The opaque surface of the soot absorbed radiant energy from the sun and converted it into heat energy.

Kind of Energy	Procedure	Observations and Conclusions
Mechanical energy	Place a *radiometer* where direct sunlight cannot strike it. Then place it in direct sunlight. Compare the results.	When the radiometer is exposed to sunlight, the vanes rotate. The blackened sides of the vanes absorb the sun's radiant energy and thus become hotter. The heated air in contact with these sides exerts a greater pressure against them than does the air in contact with the polished sides; hence the vanes rotate.

Note.—A radiometer consists of a partially exhausted bulb, within which an aluminum wheel carries four vanes blackened on one side and polished on the other.

Kind of Energy	Procedure	Observations and Conclusions
Chemical energy	Place a key on a sheet of blueprint paper, and expose to direct sunlight for a short time. Wash the paper, and allow it to dry.	Where the sun's rays strike the paper a chemical change is produced which causes the paper to turn blue. The unexposed area of the paper remains white.

Note.—Photography is based on the chemical action produced by sunlight when it strikes the silver salt on the film.

III. The Solar System.—The sun is the center of the solar system. It is a highly heated and luminous body, about 1,300,000 times the size of our earth. The following bodies are grouped around the sun:

A. Planets.
B. Moons or satellites.

C. Meteors (*shooting stars*) and comets.
D. Planetoids, or small planets.

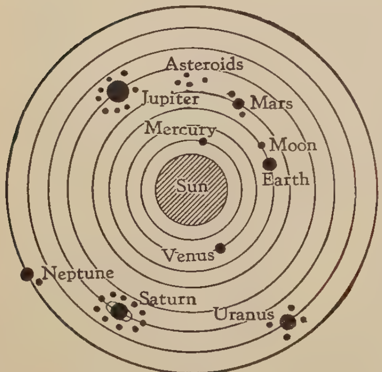


FIG. 89.—THE PLANETS WITH THEIR SATELLITES.

IV. The Planets. — The planets are large spherical masses resembling the earth in composition and movements. They do not give off light of their own, but are visible by the sunlight which they reflect. The planets, in the order of their distance from the sun, are

Mercury	Jupiter
Venus	Saturn
Earth	Uranus
Mars	Neptune

V. Satellities.—A satellite is a body which revolves around a planet just as a planet revolves around the sun. Mercury and Venus have no satellites; the other planets have from 1 to 10.

VI. Gravitation.—The planets are held in their orbits by the gravitational force exerted upon them by the sun and other heavenly bodies.

A. Every particle of matter in the universe attracts every other particle of matter. This attractive force is called *gravitation.*
B. When the earth is one of the attracting masses and some body on or above the earth's surface the other, the mutual attraction is called *gravity.*
C. The *weight* of a body is a measure of the earth's attraction for that body.

VII. Tides.—Tides are the periodic rise and fall of the ocean water caused by the gravitational pull of the moon and the sun. The tide is said to *flow* when it is rising, and to *ebb* when it is falling. There are two sets of tides: *lunar* and *solar.* The larger lunar tides dominate; the solar tides serve merely to modify the range of the lunar tides.

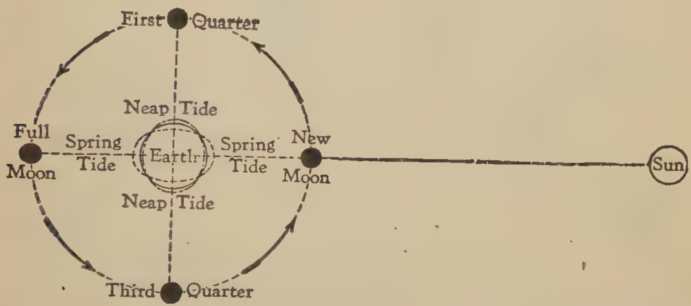


FIG. 90.—RELATIVE POSITIONS OF THE SUN, MOON, AND EARTH AT NEAP TIDE AND SPRING TIDE.

VIII. Kinds of Tides (Fig. 90)

A. *High* or *flood tide* occurs on opposite sides of the earth once every 12½ hours. It is caused by the attraction of the moon.

B. *Low* or *ebb tide* occurs on that portion of the earth's surface which lies between the points of high tide.

C. *Spring tides* are unusually high tides occurring twice a month, when the sun, earth, and moon are in line with each other.

D. *Neap tides* are low tides produced when the pull of the sun and the moon are at right angles to each other.

IX. Stars.—A star is a distant sun. It may resemble our own sun in being a hot mass of incandescent liquid or gaseous material, or it may be a distant sun which was

incandescent at one time, but has since cooled down to a dark spherical mass.

X. Constellations.—A constellation is a group of stars to which a definite name has been given. In many cases there is a resemblance in the pattern of the constellation to the name it bears, such as the *Big Dipper* or the *Corona.* Many constellations bear the names of mythological characters, with whom the ancients peopled the sky.

> **Note.**—The *Milky Way* or *Galaxy* is a tremendous group of stars containing probably 500 million suns.

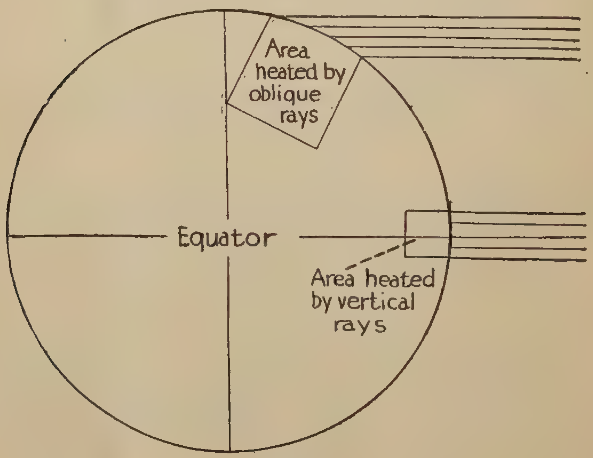


FIG. 91.

The heating effect of oblique rays of the sun is less than that of vertical rays.

XI. The Seasons.—The four seasons are caused by the periodic variation in the amount of the sun's energy received by the earth. These variations are due to

A. The inclination of the earth's axis 23½ degrees from the vertical, which causes variations in the slant of the sun's rays (Fig. 91).

B. The rotation of the earth on its axis once every 24 hours, which causes day and night.

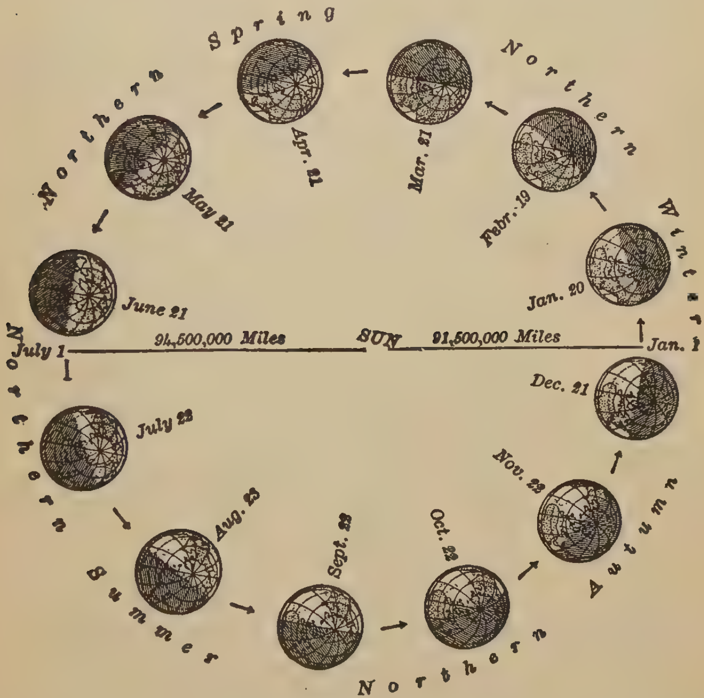


FIG. 92.—CHANGE OF SEASONS.

As the Earth revolves, the gradual turning of its axis toward, and then away from, the Sun causes the change of seasons.

C. The revolution of the earth around the sun once every year (365¼ days).

D. The varying distance of the earth from the sun. This distance varies between 92 and 94 million miles.

XII. The Causes of the Seasons. (Key experiment)

PROCEDURE

Push a knitting needle through an orange, which is to represent the Earth. Mark a point X on the orange to indicate your position. With the north pole as a center, draw a circle passing through the point X. Place a lighted candle in the center of the table. Hold the orange *south* of the light, so that the north pole points toward the North Star. Rotate the orange on its axis.

OBSERVATIONS AND CONCLUSIONS

The axis of the orange (*earth*) is now tilted at an angle of 23½ degrees to the plane of revolution of the earth, represented by the table top. As the orange (*earth*) is rotated, half of it is illuminated. More than half of the circle drawn through X is illuminated. The rays of light fall on the circle from nearly overhead. The position of the orange represents the position of the earth in *summer*, with its long hot days and short nights.

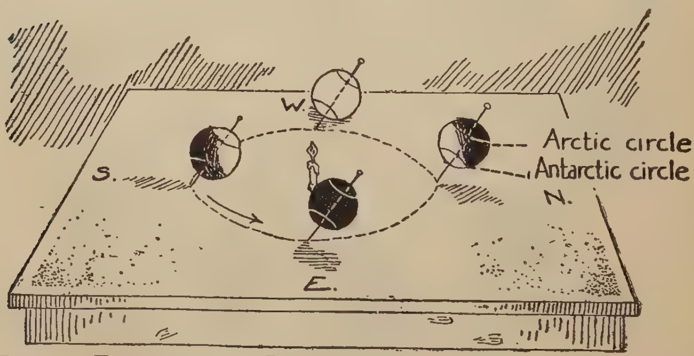


FIG. 93.—EXPERIMENT TO ILLUSTRATE THE CAUSES OF THE SEASONS.

Move the orange to a point *east* of the light, keeping the north pole pointing toward the North Star.

The circle of light reaches from pole to pole, the sun shining directly over the equator. This is the position of the earth in *autumn* (about Sept. 21), with its mild temperatures and equal days and nights.

Procedure	Observations and Conclusions
Move the orange to a point *north* of the light and rotate it on its axis.	The point X is now much longer in darkness than in light, and the rays strike it at a greater angle. This is the position of the earth in *winter,* with its short cold days and long nights.
Move the orange to a point *west* of the light and rotate it on its axis.	The rays of light now reach from pole to pole. This is the position of the earth in *spring,* when the days and nights are again of equal length.

Note.—The *Arctic Circle* is located at the point farthest north reached by the sun's rays in summer. The *Antarctic Circle* is located at the point farthest south reached by the sun's rays in winter.

XIII. Manifestations of the Sun's Energy.—The sun's energy is manifested either as active (*kinetic*) energy or as inactive or stored up (*potential*) energy.

A. *Kinetic Energy*

1. *Moving Light Rays.*—These affect photographic films, bleach cloth, turn the vanes of a radiometer, etc.
2. *Moving Air and Water.*—Caused by the sun's heat energy.
3. *Moving Objects.*—Brought about by the oxidation of fuels in machines and of foods in the bodies of living things.
4. *Oxidation of Explosives.*—The energy released during an explosion moves bullets, shatters rocks, etc.
5. *Moving Ocean Currents.*—Caused by the unequal heating of ocean water.
6. *Moving tides.*—Caused by the attraction of the sun and moon.

B. *Potential Energy*

1. Water in clouds, reservoirs, tidal dams, and oceans.

2. Objects at rèst, as in a heavy weight at the top of a pile-driver.

3. Fuels, foods, and explosives *before* they are oxidized. When these are oxidized, the sun's energy stored in them is released.

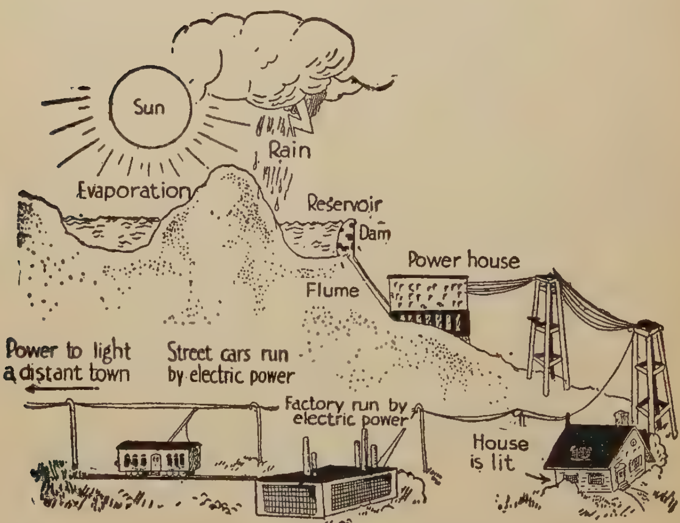


FIG. 94.—THE ENERGY IN WATER POWER COMES FROM THE SUN.

XIV. Cycles of Matter and Energy.—The sun's energy may be converted into other forms of energy. The physical laws of conservation make it possible for matter and energy to go through a number of cycles in nature.

XV. The Nitrogen Cycle

A. Nitrogen-fixing bacteria found in the nodules of leguminous plants combine atmospheric nitrogen with mineral matter in the soil, forming soluble salts which are absorbed by the roots of plants.

B. Green plants use these salts for manufacturing proteins.

C. Animals eating green plants or their products use these proteins for tissue building and release *urea*, a nitrogenous substance, as a waste product.

D. Bacteria of decay decompose urea and the bodies of dead animals, liberating free nitrogen into the air, and thus completing the nitrogen cycle.

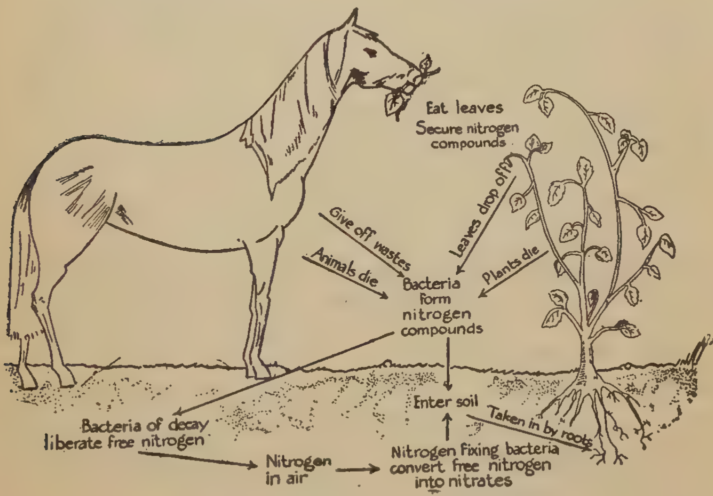


FIG. 95.—THE NITROGEN CYCLE.

XVI. The Carbon Cycle

A. Green plants use the carbon dioxide in the air in the process of photosynthesis.

B. When these plants are oxidized as foods or fuels, carbon dioxide is released into the air, thus completing the carbon cycle.

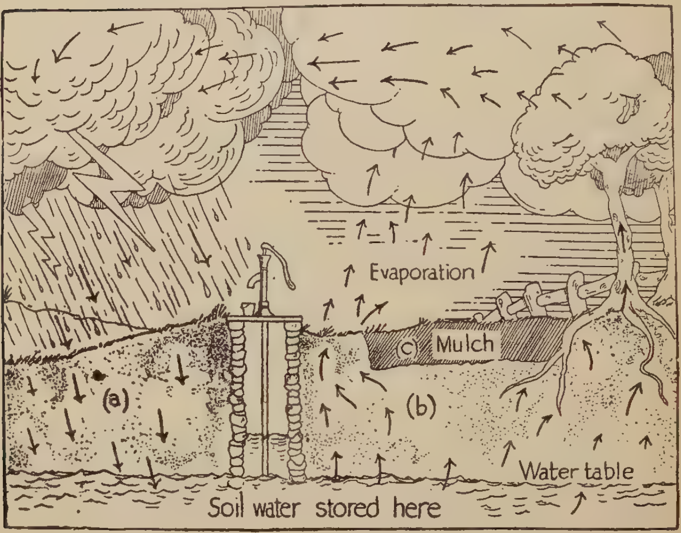


FIG. 96.—THE WATER CYCLE.

(a) The water seeps through the soil down to the water table. (b) The water rises through the soil by capillarity. (c) The mulch prevents water from rising to the surface.

XVII. The Oxygen Cycle

A. When a food or a fuel is oxidized, the free oxygen in the air combines chemically with the carbon and hydrogen in the food or fuel, forming carbon dioxide and water.

B. The carbon dioxide and water are used by green plants in the process of photosynthesis.

C. In the process of photosynthesis, the plants give off oxygen as a waste product, thus completing the oxygen cycle.

XVIII. The Water Cycle

A. The heat energy of the sun causes water to evaporate from lakes and oceans, the surface of the soil, and the leaves of plants.

B. This water vapor is pushed up to higher and cooler regions by the heavier air.

C. At the higher altitudes, the water vapor condenses and forms clouds, which give rise to rain, snow, etc.

D. The falling water soaks into the soil until it reaches the level of the "water table," or it may run off slopes into lakes and oceans.

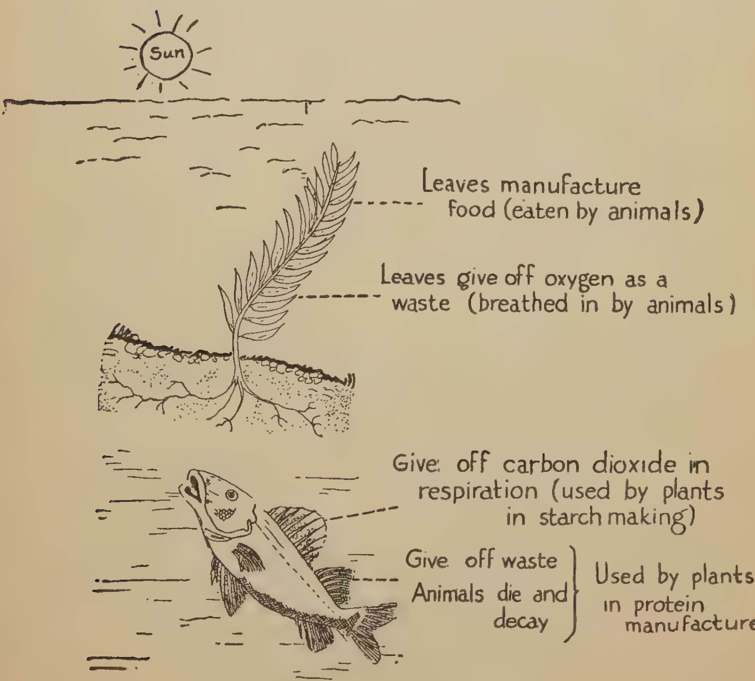


FIG. 97.—THE BALANCED AQUARIUM.

E. In dry weather, the water in the soil rises by capillary action. Plants absorb this water through their roots by the process of osmosis.

F. Water is again evaporated, as above, thus completing the water cycle.

XIX. The Balanced Aquarium.—The balanced aquarium is a self-sustaining little world of life, and illustrates the operation of the various cycles in nature. It may be made by placing, in a light spot, a glass bowl of water containing some green fresh-water plants, a few gold fish, and one or two snails.

A. The green plants supply the animals with food and oxygen.

B. The animals supply the plants with carbon dioxide and nitrogenous compounds.

XX. The Sun's Energy and Health

A. Sunlight, especially the *ultra-violet* portion, is the most powerful germ destroyer.

B. Sunlight greatly aids in the recovery of victims of tuberculosis, and is a potent preventive and cure for rickets.

C. We should admit as much direct sunlight into our homes as possible.

> **Note.**—Quartz glass and "vita" glass admit ultra-violet rays, while ordinary window glass does not.

QUESTIONS

1. (a) Of what does our solar system consist? (b) Name the planets in the order of their distance from the sun, beginning with the nearest. (c) Which one is the largest? The smallest?

2. Mention three direct and three indirect ways in which the sun furnishes energy to the earth.

3. Describe fully experiments illustrating the cause of the seasons.

4. Imagine that you are at the North Pole. Describe (a) the differences between the seasons; (b) the length of day and night in each season; (c) the appearance of the sun at different times of the year.

5. (a) Describe an experiment showing how the sun's energy may be changed into heat energy. (b) The sun's energy does not heat space. Explain.

6. What evidence is there that the sun does not revolve about the earth?

7. The days and nights are of equal length in September and March. Explain.

8. What would happen if the earth did not rotate on its axis?

9. What would happen if the earth rotated on its axis, but did not revolve about the sun?

10. What would happen if the earth inclined on its axis, but did not rotate?

11. (a) Explain how matter and energy move in cycles. (b) Give three illustrations.

12. How may the sun's rays be (a) beneficial, (b) harmful, to our health?

13. (a) What causes tides? (b) Explain why tides occur at intervals of 6¼ hours.

14. Why are tides higher at certain times than at others?

15. By what names are the following known: (a) very high tides; (b) very low tides; (c) average tides?

CHAPTER XVII

THE IMPROVEMENT OF LIFE

I. Evolution.—The term *evolution* is used to signify the gradual changing of organisms to fit them better to their environment. It involves the following two basic ideas:

A. The higher forms of life have resulted from the gradually increasing complexity of lower forms of life.

B. This increase in complexity was necessary for the organisms to survive in their increasingly complex environment.

II. Theories of Evolution.—Three theories have been advanced to account for the process of evolution by Darwin, Lamarck, and De Vries.

III. Darwin's Theory

A. Organisms produce more offspring than can possibly be provided for. This results in a *struggle for existence.*

B. All individuals vary (*variation*). Some are better fitted than others for the struggle for existence.

C. The individuals that are best fitted survive and reproduce (*natural selection* or *survival of the fittest*).

D. The variations that permitted these individuals to survive are passed on to their offspring (*heredity*).

E. Those that are not adapted to their environment die, and their kind becomes extinct.

IV. Lamarck's Theory

A. *Law of Use and Disuse.*—An organ develops when it is used, and degenerates or disappears when it is no longer needed.

B. As new needs arise, Nature develops organs to satisfy these needs. A new use of an existing organ results in a change in its structure.

> **Note.**—The last part of Lamarck's Theory is not accepted by most biologists.

V. De Vries' Theory

A. Hugo De Vries, a Dutch naturalist, while experimenting with primroses, discovered a new sort of primrose which had *suddenly* developed, and which he called a *mutant* (Latin word meaning *changed*). Mutants occur very seldom, and are usually discovered accidentally.

B. Mutants transmit their characteristics to their offspring.

> **Note.**—This theory is sometimes called the *Mutation Theory.*

VI. Illustrations of De Vries' Theory

A. A Pennsylvania farmer discovered three heads of "beardless" wheat in a large field of "bearded" wheat. He planted these *mutants* by themselves, and soon obtained enough seed to start the growing of "beardless" wheat everywhere.

B. Shortly after the Revolutionary War, a New Englang farmer found in his flock a lamb that had very short legs and a long back. From this mutant *Ancon sheep* were developed. These sheep were considered valuable because they could not jump over fences. This breed is now extinct, the small demand for it causing its breeding to be discontinued.

VII. Evolutionary Improvement.—The improvement of a race by evolution depends upon three factors:

A. *Variation.*—All individuals are different from one another.

1. Variation may occur in nature suddenly, and to such an extent as to be termed mutation. Mutants result from mutations.
2. Variation may be brought about artificially by the production of *hybrids.*

B. *Selection*

1. *Natural Selection.*—Those individuals that are best fitted survive.
2. *Artificial Selection.*—Man deliberately selects and breeds plants and animals for any desired result.

C. *Heredity.*—The tendency of offspring to inherit the characteristics of their parents.

VIII. Hybridization.—Certain *closely related* species of plants and animals sometimes reproduce by the union of their respective sperm and egg cells. A mixed species, or *hybrid,* thus results.

Examples

1. Luther Burbank created the **plumcot** (a hybrid species of a plum and an apricot), the "white" blackberry, the spineless cactus, the "climax" plum (a hybrid species of Japanese and Chinese plums), and many other hybrid flowers, fruits, and berries.
2. Some animal hybrids are the mule (from a horse and a donkey) and the wolf dog (from a dog and a wolf).

IX. Mendel's Laws of Heredity.—As a result of experiments with sweet peas in his garden, Gregor Mendel, an Austrian monk, formulated certain laws which govern characteristics transmitted by parents to their offspring. These are discussed in the following paragraphs.

X. Law of Unit Characters.—Single traits or characters (color or size of flowers, seeds, etc.) are transmitted to the next generation without being lost or mixed.

> **Example.**—The inheritance of tallness or shortness of the sweet peas was quite independent of the inheritance of color.

XI. Law of Dominance.—When two plants having opposite characters are crossed, the resulting hybrid acquires the characters of both parents, but one of a pair of opposite characters is always *hidden*. The character which appears, Mendel called *dominant;* the other (hidden) character he called *recessive.*

XII. Illustration of the Law of Dominance.—When Mendel crossed pollinated tall-stemmed peas with short-stemmed peas, only tall-stemmed peas grew. The character of shortness was present but concealed. Similarly, when he crossed red peas with white peas, only red peas appeared, the character of whiteness remaining hidden. In these examples, the tallness and redness were *dominant characters;* the shortness and whiteness, *recessive characters.*

XIII. Law of Segregation.—When hybrids are crossed, the characters separate out again in the ratio of three dominants (one pure, others mixed) to one pure recessive.

XIV. Illustration of the Law of Segregation.—When Mendel planted hybrid red peas with the character of whiteness concealed, he found that

A. One-fourth of the seeds developed into red peas which always reproduced red peas, the red character having been pure.
B. One-fourth developed into white peas, which always reproduced white peas, the white character having been pure.
C. One-half developed into red hybrid peas, with the character of whiteness concealed. In the next generation, these hybrid peas reproduced in the ratio of one-fourth red, one-fourth white, and one-half red hybrid, as before.
D. The same ratio continued through succeeding generations.

XV. Law of Pure Breds.—Pure dominants always produce pure dominants; pure recessives always produce pure recessives.

XVI. Human Dominant and Recessive Characters.—The following table gives some of the characters in man that have been proved to be inheritable in accordance with Mendel's Laws.

DOMINANT	RECESSIVE
Black or brown eyes	Blue or gray eyes
Dark hair	Light hair
Dark skin	Light skin
Extra digit	Normal number of digits
Curly hair	Straight hair
Nervousness	Normal type
Normal mind	Feeblemindedness

XVII. Eugenics.—The word *eugenics* is derived from the Greek word *eugenes*, which means *well born*. It is applied to the principle of artificial selection as applied to man. The science of eugenics proposes the restriction of marriage to

those who are known to be fit to become parents. Tendencies to feeblemindedness and other handicaps which should not be handed down to posterity would thus be eliminated.

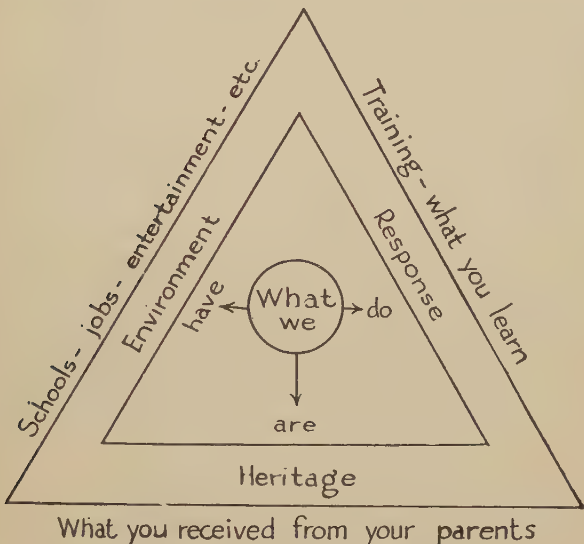


Fig. 98.—The Triangle of Life.

XVIII. How Heredity Operates in Man.—Life is influenced by three great factors, often referred to as the *triangle of life.*

A. *Education.*—Education plays a very important part in determining the motives and actions of every individual.

B. *Environment.*—Environment does much to regulate the character, tastes, habits, and physical development of an individual.

C. *Heredity.*—In addition to the influences exerted upon us by education and environment, we are what we are largely through the factor of heredity. The

characteristics of our ancestors affect us, and through us these characteristics affect many future generations.

XIX. The Jonathan Edwards Family.—The history of the descendants of Jonathan Edwards, a distinguished preacher and former college president, shows that good ancestry begets good descendants. All of his more than a thousand descendants were distinguished citizens—physicians, college professors, clergymen, lawyers, public officials, etc.

XX. The Kallikak Family.—The history of this family shows the effects of both good and bad ancestry on the descendants. Martin Kallikak, a man of excellent family, married a feeble-minded girl. The history of 480 descendants of this marriage shows that 143 were feeble-minded, and that many others were paupers, drunkards, thieves, and other undesirables. Kallikak later married a normal girl of good ancestry. Of this marriage 496 descendants have been traced, not one of whom was feebleminded.

XXI. The Jukes Family.—The history of the Jukes family begins with Margaret, "the mother of criminals." Of the 2094 descendants of this family on record, 1600 were either feeble-minded or epileptic, 310 were paupers, and 140 were criminals. The Jukes family and its descendants have cost the State of New York more than $2,500,000.

XXII. Factors in Race Improvement.—Improvement in heredity is closely linked with other factors of race improvement, such as

A. *Cleanliness*, the fight against disease largely caused by an unfavorable environment.

B. *Proper environment*, such as fresh air, sunlight, etc.

Note.—The science of the improvement of environment is called **euthenics.**

C. *Proper Hours of Labor.*—Mothers should not work outside the home while caring for their children. Persons who are weakened by overwork are more susceptible to disease, and diseased parents often transmit undesirable qualities to their children.

QUESTIONS

1. (a) What is meant by *evolution?* (b) Discuss the theories advanced to explain it.

2. Explain the meaning of (a) struggle for existence; (b) survival of the fittest.

3. *Define*: (a) heredity; (b) artificial selection; (c) variation; (d) eugenics; (e) euthenics.

4. What is meant by the term *hybridization?* Illustrate.

5. (a) State Mendel's *first law of heredity.* (b) Give examples to illustrate the operation of this law.

6. What is the *law of unit characters?* Illustrate.

7. (a) State the *law of segregation.* (b) Illustrate by an example.

8. (a) What are *mutants?* Give examples. (b) Name the man who first discovered the existence of mutants.

9. Explain and illustrate the meaning of (a) dominant characters; (b) recessive characters.

10. (a) What three great factors influence our lives? (b) Explain how these factors operate.

11. Explain how the "triangle of life" exerts an influence on your future life.

12. How should the science of eugenics deal with such problems as were created by the Kallikaks?

DEFINITIONS

Absolute humidity.—The weight of water vapor in a unit volume of air (*e.g.,* 4 grains per cubic foot).

Absorption.—The process whereby digested food is taken into the blood from the intestines.

Accommodation (of the eye).—The ability of the lens of the eye to change its focal length for objects at different distances.

Acetanilid.—A chemical found in many patent medicines, especially in headache and cold remedies, which slows up the action of the heart.

Acid.—A compound whose water solution has a sour taste and turns blue litmus red.

Adaptation.—The adjustment of an organism to its environment.

Adenoids.—Growths in the passage leading from the nose to the throat.

Adulterant.—A cheap or non-nutritious substance added to a food or substituted for a part of it with the view to cheating the purchaser.

Albumen.—A protein material. The white of an egg.

Ampere.—The unit of current strength. The amount of current produced by an electrical pressure of 1 volt acting through a resistance of 1 ohm.

Anther.—The portion of the stamen of a flower which contains pollen.

Antibodies.—Substances in the blood which fight harmful bacteria and counteract their toxins.

Anti-cyclone.—A region of high pressure, clearing weather, and low temperature. The opposite of cyclone.

Antiseptic.—A substance which prevents the growth of microscopic organisms.

Antitoxin.—A substance that neutralizes a toxin.

Armature.—A piece of soft iron connecting the poles of a magnet. A revolving coil of wire used to pick up induced currents in a dynamo. The coil revolving between the poles of a powerful magnet, as in the electric motor.

Artery.—A blood vessel which carries blood from the heart.

Aseptic.—Free from disease germs.

Assimilation.—The transformation of digested food into living matter (*protoplasm*).

Astigmatism.—A defect of the eye due to the irregularity in the curvature of the eye-ball.

Atmosphere.—The mass of air surrounding the earth.

Atom.—The smallest particle of an element that can take part in a chemical change.

Auricles.—The thin-walled upper two chambers of the heart which receive blood from the veins.

Bacillus.—A rod-shaped bacterium.

Bacteria.—Microscopic one-celled plants. The smallest and simplest forms of plant life known.

Bacteriology.—The study of bacteria.

Bile.—A fluid secreted by the liver.

Biology.—The study of living things, both plants and animals.

Buoyancy.—The upward force which a liquid or gas exerts on any body submerged in it.

Caisson.—A water-tight chamber filled with compressed air in which men can work under water.

Calorie (large).—The amount of heat required to raise the temperature of 1 kilogram of water 1° C.

Calyx.—The external part of a flower, usually green and leaf-like.

Capillaries.—Minute blood vessels connecting arteries with veins.

Capillarity.—The elevation or depression of liquids in tubes of small diameter.

Carbohydrate.—A substance composed of carbon, hydrogen, and oxygen.

Carburetor.—An apparatus designed for mixing air with the vapor of any light petroleum oil, such as gasoline.

Cell.—The structural and physiological unit of plant and animal tissues.

Cell membrane.—The delicate covering of a cell composed of living material.

Cell sap.—The clear liquid in the cytoplasm of plant cells.

Cellulose.—A woody substance found in the walls of plant cells.

Chemical change.—One involving a change in the composition of the substance (*e.g.*, rusting of iron; digestion of food). The properties of the substance undergoing the change are permanently altered.

Chemical compound.—A substance containing two or more elements chemically united.

Chemical element.—A substance which has not yet been decomposed into simpler substances.

Chlorophyll.—The green coloring matter in leaves.

Chromosomes.—Color-bearing bodies in the nucleus of a cell, which carry hereditary traits.

Chronometer.—An accurate clock set to Greenwich time.

Coccus.—A spherical-shaped bacterium.

Combustion.—Any chemical reaction producing noticeable heat and light.

Communicable disease.—A disease that can be passed on from one person to another.

Commutator.—A device for changing the alternating current in the armature of a dynamo into a current which flows in one direction in the external circuit.

Condensation.—The process of changing a substance from the gaseous to the liquid state.

Conduction.—The transmission of heat from one part of a body to another, or from a hot body to a cold body, by molecular collision.

Cornea.—The transparent portion of the coat of the eye covering the iris and pupil.

Corolla.—The petals of a flower, taken together.

Corpuscles.—The red nucleated cells and colorless cells in the blood.

Culture.—The growth of bacteria or other microörganisms in a prepared nutrient medium.

Cyclone.—An area of winds rotating about a calm center of low atmospheric pressure.

Cyst.—A hard coat formed around protozoa and bacteria, which enables them to withstand unfavorable conditions.

Cytoplasm.—The living substance in a cell, surrounding the nucleus.

Damper.—A valve or a plate used to regulate the draft in a stove, furnace, etc.

Declination (magnetic).—The angle between the direction of the magnetic needle and the meridian at any place.

Degree.—One 360th part of the circumference of a circle.

Dentine.—The material forming the main part of a tooth.

Detector.—A device for allowing alternating (or oscillating) radio waves to pass along a circuit in one direction only.

Diaphragm.—A muscular partition separating the chest cavity from the abdominal cavity.

Diastase.—An enzyme found in plants which changes starch to grape sugar.

Diffusion.—The gradual mixing of gases or liquids, without the application of an external force.

Digestion.—The process by which food is made soluble and ready for absorption.

Disinfectant.—A substance which kills bacteria.

Distillation.—The process of boiling a liquid and condensing its vapor.

Draft.—A device in a stove or furnace for regulating the amount of air admitted.

Dry farming.—A method of soil cultivation employed where there is insufficient moisture.

Dynamo.—A machine for transforming mechanical energy into electrical energy.

Eclipse.—The interposition of a dark celestial body between a luminous celestial body and the eye.

Electrolysis.—The decomposition of a compound by means of the electric current.

Electron.—A particle of negative electricity. A constituent of the atoms of all elements.

Embryo.—An early stage in the development of a plant or an animal.

Emulsion.—A mixture of one liquid in another in which separation takes place very slowly (*e.g.,* cream in milk).

Enamel.—The hard outer covering of the upper part of a tooth.

Energy.—The ability to do work.

Environment.—The surroundings of an organism.

Enzyme.—A material found in digestive juices which brings about the digestion of food.

Epidemic.—A disease attacking many organisms at the same time.

Epidermis.—An outer layer of cells.

Erosion.—The wearing away of the earth by wind and water.

Esophagus.—A muscular tube leading from the pharynx to the stomach.

Essential organs of a flower.—The stamens and the pistils—the parts of a flower which are essential for the production of seeds.

Eugenics.—The science which deals with race improvement through heredity.

Eustachian tubes.—Canals leading from the tympanic cavities to the pharynx.

Euthenics.—The science which deals with race improvement through the betterment of the environment.

Evaporation.—The process of converting a liquid into the gaseous state by heating.

Excretion.—The elimination of waste matter resulting from the breaking down of protoplasm.

Fallowing.—Allowing land to lie idle in order to restore to it important substances removed through previous cultivation.

Far-sightedness.—A defect of vision caused by the insufficient convergence of the lens of the eye. The images of objects are brought to a focus *beyond* the retina.

Fats.—A group of nutrients composed of much carbon and hydrogen and little oxygen.

Ferment.—An agent capable of producing fermentation (*e.g.,* yeast).

Fermentation.—A chemical action caused by living organisms or enzymes. It usually results in the production of alcohol and carbon dioxide.

Fertilization.—The union of a sperm cell with an egg cell.

Fertilizer.—A commercial manure for land, such as guano, bone dust, etc.

Fibrin.—A white, insoluble protein, formed when blood clots.

Fibrovascular bundles.—Collections of tubular cells, supported by woody cells, which conduct fluids in plants.

Filament.—A thin white stalk supporting the anther of a flower.

Fission.—The division of a cell into two cells of equal size.

Fixation of nitrogen.—The process of converting atmospheric nitrogen into useful compounds.

Flame.—A burning gas or vapor.

Fog.—A cloud very near the earth.

Food.—A substance which supplies material for the growth and repair of the tissues of a plant or an animal, or which furnishes it with energy.

Foot-pound.—The amount of work done by a force of 1 pound acting through a distance of 1 foot.

Force.—That which changes or tends to change the state of rest or of motion of a body.

Friction.—The resistance that opposes the motion of one body over another.

Fruit.—A ripened ovary together with any parts of the flower that may be attached to it.

Fumigation.—The process of generating gases or fumes which kill disease-producing bacteria.

Fuse.—A piece of metal inserted in an electric circuit, which melts when the current increases beyond the limit of safety, thus breaking the circuit.

Gastric glands.—Digestive glands in the walls of the stomach which secrete gastric juice.

Germicide.—A substance that kills germs.

Germination.—The sprouting of a seed to form an adult plant.

Gland.—An organ of secretion which manufactures substances useful to the body.

Glycogen.—Animal starch found in the liver.

Gravitation.—The attraction between any particle of matter and every other particle of matter in the universe.

Gravity.—The attraction between the earth and all bodies.

Haemoglobin.—The red coloring matter of blood.

Heredity.—The transmission of characteristics from parent to offspring.

Highs.—Regions of high atmospheric pressure.

Hilum.—The scar on the testa of a seed, which marks the point of attachment of the seed to the placenta of the mother plant.

Horse-power.—The rate of working that will accomplish 33,000 foot-pounds per minute (550 foot-pounds per second).

Humidity.—The amount of water vapor in the air.

Humus.—Decaying organic material in the soil.

Hybrid.—An offspring produced by crossing two different species of plants or animals.

Hygiene.—The science of the preservation of health.

Hygrometer.—An instrument for measuring the amount of atmospheric humidity.

Igneous.—Resulting from the action of intense heat (*e.g.*, igneous rocks).

Image.—The optical counterpart of an object.

Immunity.—The resistance of an organism to infection by microörganisms.

Impenetrability.—A general property of matter by virtue of which no two portions of matter can occupy the same space at the same time.

Induction (magnetic).—The process of magnetizing a substance by placing it near a magnet or in a magnetic field.

Inertia.—The property, possessed by all matter, of resisting any attempt to set it in motion if it is at rest, to stop it if it is in motion, or to change its motion either in speed or in direction.

Infection.—The transmission of disease by a diseased organism or through the medium of air, water, food, clothing, etc.

Inoculation.—The process of infecting an organism with a disease by injecting into its blood the virus (weakened germs) of the disease, so as to produce a mild form of the disease and thereby establish future immunity.

Inorganic.—Not formed by, or derived from, a living organism.

Insulator of electricity.—A substance which cannot transmit electrical charges (*e.g.*, rubber, glass, etc.).

Insulator of heat.—A substance which is a poor conductor of heat (*e.g.*, wood, glass, etc.).

International date line.—An irregular, imaginary line near the 180th meridian by which one makes a correction in time when traveling round the world.

Iris.—The colored portion of the eye surrounding the pupil.

Irrigation.—The process of artificially supplying land with water for the use of plants or crops.

Kilowatt.—A unit of electrical power. (1 kilowatt = 1000 watts). The power of dynamos and electric motors is expressed in terms of kilowatts.

Kilowatt-hour.—The amount of energy furnished in one hour by an electric current whose power is 1 kilowatt.

Kindling temperature.—The lowest temperature at which a substance begins to burn.

Kinetic energy.—The energy which a body possesses because of its motion.

Larva.—A stage in the life history of an organism when the young does not resemble its parent.

Latitude.—Distance in degrees north or south of the equator.

Legumes.—Plants which bear seeds in pods (*e.g.*, peas, beans, clover, etc.). Also the fruits or seeds of such plants.

Lens.—A portion of a transparent material, usually glass, bounded by one or more curved surfaces.

Lever.—A rigid bar, supported on an axis, called the fulcrum, about which it can rotate.

Liver.—A digestive gland which secretes bile and acts as a storehouse for glycogen.

Loam.—Soil rich in decaying organic matter.

Longitude.—The distance in degrees east or west of the prime meridian at Greenwich.

Lows.—Low pressure areas, or cyclone areas.

Lymph.—Plasma and colorless corpuscles outside the blood vessels.

Machine.—A device designed to change the magnitude or the direction of a force required to do useful work. A device used for transforming or transferring energy.

Manometer.—An instrument for measuring fluid pressure.

Metamorphic rocks.—Rocks whose composition was changed by water, heat, and pressure.

Mitosis.—The changes that take place in the nucleus before cell division takes place.

Molecule.—The smallest particle of a substance which has the properties of the substance.

Mulch.—Any substance, such as straw or a layer of fine soil, used to prevent the drying up of soil or to protect roots from extremes of temperature.

Mutant.—A new variety of an organism that appears suddenly ("sports").

Narcotic.—A substance which dulls the senses and may cause death.

Near-sightedness.—A defect of vision caused by the excessive convergence of the lens of the eye. The images of objects are brought to a focus *in front* of the retina.

Nebula.—A faint, cloud-like, self-luminous mass of gaseous matter in the heavens.

Nodule.—A small lump found on the roots of leguminous plants which contains nitrogen-fixing bacteria.

Nucleus.—The center of vital activity in a living cell.

Nutrients.—Organic food substances.

Ohm.—The unit of electrical resistance.

Opaque body.—A body which does not permit light to pass through it.

Examples.—Wood, granite, iron.

Orbit.—The path in which one heavenly body revolves about another.

Organic substance.—A substance that is either alive or was produced by a living organism.

Osmosis.—The process whereby two liquids or gases of unequal density, separated by a membrane, tend to pass through the membrane and mingle with each other, the greater flow being toward the denser liquid or gas.

Ovary.—The organ of a plant or an animal which produces egg cells.

Oxidation.—The process whereby oxygen unites with some other substance.

Oxide.—A compound of oxygen with one other element.

Parasite.—An organism which lives upon, and takes its food from, another organism without giving it anything in return.

Pasteurization.—The heating of milk to a temperature of 160° F. for about 30 minutes in order to destroy harmful bacteria.

Pathogenic organisms.—Organisms which cause disease.

Penumbra.—The lighter portion of a shadow caused by the partial exclusion of light.

Phagocytes.—Colorless corpuscles in the blood which destroy germs.

Photosynthesis.—The process by which green leaves, aided by sunlight, manufacture starch from carbon dioxide and water.

Physical change.—One which does not involve a change in the composition of a substance (*e.g.*, breaking glass).

Physiology.—The study of the functions or work of the organs of living things.

Plasma.—The colorless, liquid portion of the blood.

Pollen grains.—Tiny bodies in the anther of a flower which contain the sperm cells.

Pollination.—The transfer of pollen grains from the anther to the stigma of a flower.

Power.—The time rate of doing work.

Proteins.—Nitrogenous compounds in the bodies of plants and animals. A class of nutrients composed chiefly of carbon, oxygen, hydrogen, and nitrogen.

Protoplasm.—The living substance of plants and animals.

Ptomaine.—A poisonous substance produced by the action of putrefactive organisms on proteins.

Ptyalin.—The enzyme contained in saliva.

Putrefy.—To cause to rot or decay.

Quarantine.—The isolation of organisms from others to prevent the spread of disease.

Radiation.—The transfer of heat or light by means of ether waves.

Recessive characters.—Characteristics not apparent in a hybrid.

Reflection.—The bending back of a ray or a beam of light when it strikes a surface.

Refraction.—The bending of a ray or a beam of light when it passes obliquely from one medium into another of different optical density.

Relative humidity.—The amount of water vapor which the air holds compared with what it *could* hold at the given temperature if it were saturated.

Respiration.—The process by which a living organism takes in oxygen, oxidizes food, and gives off carbon dioxide and water vapor.

Retina.—The coat of the eye in which the optic nerve terminates.

Rheostat.—A device for regulating the amount of electric current flowing through a conductor.

Rotation of crops.—The practice of planting a different crop on a plot of land at each replanting, in order to prevent the loss of important soil ingredients and to help control weeds, fungi, etc.

Saprophyte.—A plant which obtains its nourishment from dead and decaying vegetable matter (*e.g.*, mushrooms, molds).

Seed.—A baby plant with its food supply.

Septic substance.—A substance that causes putrefaction.

Sextant.—An instrument for determining latitude and longitude by obtaining the altitude of heavenly bodies.

Shadow.—When an opaque body is placed between a source of light and a screen, the space is darkened on the side of the

opaque body away from the source of light. This darkened space is the shadow of the body.

Smoke.—Small particles of carbon floating in the gaseous wastes from burning organic matter, which finally settle as soot.

Solute.—A dissolved substance.

Solvent.—A liquid used to dissolve a substance.

Spore.—A reproductive cell usually produced by asexual means.

Stamen.—The male organ of a flower.

Sterilization.—The process of destroying germs, usually by means of heat.

Stigma.—The part of the pistil of a flower which receives pollen grains.

Stimulant.—A substance which increases the activity of the nervous system.

Stomata.—The breathing pores in a leaf.

Tissue.—A group of similar cells having the same function.

Toxins.—Poisons produced by parasitic bacteria.

Translucent body.—A body which permits light to pass through it, but diffuses this light so that objects cannot be clearly seen through it.

Examples.—Ground glass, wax paper, egg shell.

Transparent body.—A body which permits light to pass through it so well that objects can be clearly seen through it.

Examples.—Glass, clear quartz, water, air.

Transpiration.—The giving off of water from the leaves of a plant.

Turbine.—A motor having curved vanes, which is made to rotate by the pressure exerted by water or jets of steam.

Umbra.—The part of the shadow of an object from which all light is excluded.

Urea.—A nitrogenous waste material in urine.

Vaccination.—The inoculation of a vaccine (dead or weakened germs) into the blood stream to protect the body from disease.

Vapor.—Any substance in the gaseous state.

Vitamins.—Substances in foods which are necessary to health.

Volt.—The unit of electrical pressure. The pressure that will send a current of 1 ampere through a resistance of 1 ohm.

Watt.—The rate at which energy is expended by a current of 1 ampere in that portion of a circuit the terminals of which have a potential difference of 1 volt.

Weathering.—The effect of water, oxidation, freezing, thawing, etc., on rocks.

Work.—Whenever a force acts upon a body in such a manner that it causes the body to *move,* it is said to do work upon that body.

Zoology.—The study of animals.

MISCELLANEOUS QUESTIONS

1. Can an airplane remain in the air without moving? Give a reason for your answer.

2. To pour condensed milk from a can, two holes are usually punched in the top, at opposite sides. Why is the second hole necessary?

3. Why is it very tiring to walk in mud?

4. What is *suction?* Is it a push or a pull?

5. What causes the ''pop'' when you burst a paper bag?

6. Explain how a parachute works.

7. Why does a barometer give the same reading indoors as outdoors?

8. Explain why automobile tires are filled with air rather than with water.

9. What causes a balloon to rise? To sink?

10. (a) Assuming that you weigh 125 lbs., what weight of water do you displace when you float? (b) How many cubic feet of water do you displace? (c) What is the volume of your body in cubic feet?

11. Explain how a submarine is made to (a) rise, (b) sink.

12. Why does cream ''rise'' to the top of milk?

13. Will a ship carry a heavier load in fresh water or in salt water? Give a reason for your answer.

14. Why is it difficult to ventilate a room on a hot day unless a breeze is blowing?

15. Sprinkling the floor on a hot day cools the air in the room. Explain.

16. (a) What is "cold"? (b) Why is it so cold on mountain tops?

17. If the barometer reads 29.5 at Albany, N. Y., and 30 at New York City, from what direction is the wind likely to blow in the latter city?

18. Sometimes rain starts falling during the night and ceases when the sun rises. Explain.

19. Why does dew seldom form during (a) a windy night; (b) a cloudy night?

20. Fruit growers make a smudge when frost threatens. Explain.

21. Explain what happens when moist winds from the ocean strike a mountain range.

22. Railway rails are laid with a small space between their ends. Explain.

23. Why does blowing on a burning match extinguish it, while a good draft is necessary for a furnace fire?

24. Why do the hands become cold when washing something with gasoline?

25. Why are tall chimneys best suited for blast furnaces?

26. In starting a coal fire, paper, wood, and coal are usually added successively. Explain.

27. Why does a pan held over a luminous flame become black?

28. Upon what does the efficiency of a thermos bottle depend?

29. Explain how food is cooked in a fireless cooker.

30. The walls of ice-houses are usually packed with sawdust. Explain.

31. Why is water a better substance for a foot-warmer than iron?

32. Explain why alcohol is frequently used in automobile radiators in winter.

33. How do "desert bags" keep water cool?

34. Potatoes will not cook more quickly in water boiling vigorously than in water boiling gently. Explain.

35. Explain how you would adjust a gas burner so that it will not "pop" back.

36. The composition of the air is fairly constant. Explain how this is accomplished.

37. A balanced aquarium resembles the world of living things. Explain.

38. Explain why burning does not consume all the oxygen in the air.

39. Can a barometer indicate a pressure of 30 in. even though it is raised 1000 ft. above sea level? Give a reason for your answer.

40. What prevents the earth from being covered with the bodies of dead plants and animals?

41. Explain how the composition of the soil is kept fairly constant.

42. Why is the soil red in many localities?

43. (a) Account for the salty taste of ocean water. (b) Why is not rain water salty?

44. What is a fertile soil?

45. Farmers sometimes plant clover and, after it has grown, plow it under. Explain.

46. Compare the world to a greenhouse.

47. State your reasons for believing that oxidation takes place in the human body.

48. Explain why milk is such a beneficial food.

49. Explain how the human body obtains its energy from the sun.

50. Why do arctic tribes feed largely on blubber or fat?

51. Ice is always placed in the *top* of a refrigerator. Explain.

52. Is it wise to wrap the ice in a refrigerator in a blanket or newspaper?

53. The common house-fly was considered to be more dangerous than bullets during the Spanish-Amerrican War. Explain.

54. Account for the fact that France was unable to build the Panama Canal, while the United States succeeded.

55. After recovering from certain diseases, such as measles or typhoid fever, a person is not likely to contract the same disease. Explain.

56. Explain why the process of filtration removes sediment from water, but will not remove salt.

57. Mountainous wooded regions are best suited for a city water supply. Explain.

58. (a) What causes "hardness" in water? (b) How may it be removed?

59. What phase of the moon must be present when it is directly overhead at midnight? Explain.

60. (a) Why do we use time belts? (b) What is the International Date Line?

61. Explain why the outside rail of a railroad track is placed higher than the inner one on a curve?

62. Why do sparks fly from a car wheel when the brakes are applied?

63. What is the source of energy in gasoline or kerosene?

64. Why do automobile engines sometimes "back-fire"?

65. Explain how carburetors are regulated.

66. What causes carbon to collect in the cylinders of a gas engine?

67. Explain how you can determine which spark plug of a gas engine fails to fire.

68. Why does the earth never stop moving?

69. Why is one thrown forward violently when his bicycle strikes an obstacle?

70. It is easier to balance oneself on a bicycle when the speed is increased. Explain.

71. Why are your feet warmer when your shoes are polished?

72. Describe the process of silver-plating.

73. What are the essential parts of a voltaic cell?

74. Explain why the voltage is marked on electric light bulbs.

75. What causes a telegraph instrument to "click" when the key is pressed?

76. Why are "dry cells" so called?

77. Indians and scouts often place their ears to the ground to hear the approach of others. Explain.

78. Explain why thunder causes a house to shake.

79. Why are telephone wires strung on glass supports?

80. Why are particles of carbon placed in telephone and radio transmitters?

81. Account for the fact that birds can sit on a "live" trolley wire without getting a shock.

82. Trace the course of a drop of water from the ocean, from the time it leaves the ocean until it helps operate an electric dynamo at a waterfall.

83. When pins are stuck through the insulation of an electric cord, a fuse will "blow out." Explain.

84. Explain why the bare wires leading to an electric device should never be allowed to touch each other while the current is flowing through the wires.

85. Why is it dangerous to turn on an electric light or switch while standing on a cement, iron, or wet earthen floor, unless you are wearing rubbers?

86. White clothing is best suited in summer and dark clothing in winter. Explain.

87. Account for the blue color of the sky.

88. Account for the fact that there are so few green flowers.

89. Explain why aviators at a great height cannot see the earth revolve.

90. What is it that generates heat inside of an electric flatiron?

91. Why must photographic films be developed in a red light?

92. The sun causes clothing to fade, but not flowers. Explain.

93. Describe the pin-hole camera.

94. Explain why we can see the sun after it has "set" and before it has "risen"?

95. If you stand on a bank, how should you aim a gun in order to shoot a fish in the water?

96. Why do some wall-papers appear darker than others, even though they are illuminated by the same amount of light?

97. In what respects do radio waves differ from light waves?

98. Explain how a ship at sea can find its position with the aid of a radio apparatus.

99. Explain why a fire in a grate causes a draft up the chimney.

100. Why is it difficult to maintain a relative humidity of from 40–60 per cent in our homes during cold weather?

RECENT EXAMINATION PAPERS

(*New York State Board of Regents*)

Tuesday, January 26, 1932—1.15 to 4.15 p. m., only

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions. Answers to any of the last five questions should be written on the question paper as directed and handed in with the other answer paper.

1 Make a labeled diagram of an experiment to show *each* of the following:

a The formation of an image of a tree in a pinhole camera or in the human eye. [5]

b The necessity of light for the making of starch. [5]

2 *a* Name *three* conditions favorable to the growth of bacteria. [3]

b Describe an experiment to prove that *one* of the conditions named in answer to *a* is favorable to bacterial growth. [4]

c Mention *three* ways in which bacteria are of use to man. [3]

3 Give a reason for *each* of the following: [10]

a Metal tanks are frequently painted.

b Leather will mold when left in a damp place.

c A column of mercury will rise or fall in a thermometer.

d Water is often used to put out a fire.

e Paper, wood and coal are often used to start a furnace fire.

4 *a* Give *two* reasons why circulation is necessary in plants and animals. [4]

b State *two* reasons why the removal of waste from the cells is necessary. [2]

c What changes take place in the composition of the blood in the capillaries of (1) the small intestine, (2) the kidneys? [4]

5 You are asked by your teacher to demonstrate before the class that air exerts pressure.

a Make a labeled diagram to show the apparatus properly assembled. [3]

b Tell fully how you used the apparatus and what you observed. [3]

c Explain how, in the human body, breathing depends on atmospheric pressure. [4]

6 *a* Make a labeled diagram of a plant cell or an animal cell. [2]
b State the function of *each* part that you have labeled. [3]
c Name the living substance that makes up all plant and animal cells. [1]
d Name *four* elements found in this substance. [2]
e Name *one* structure found in a plant cell that is not found in an animal cell. [2]

7 *a* State *two* harmful effects of the use of alcohol on *each* of the following organs: heart, stomach, brain. [6]
b What is the general effect of a narcotic? [2]
c Explain why so-called headache cures are often harmful. [2]

8 *a* Mention an important contribution or discovery that has been made in science. [2]
b Show how this contribution has advanced the welfare of mankind. [4]
c Name two diseases for each of which science has not yet found the cause. [4]

9 *a* Name *four* weather factors (conditions) that prevail in a "low" area. [4]
b Name *four* instruments used in recording the weather. [4]
c Explain how *one* of these instruments works. [2]

10 *a* Name *one* animal fitted by structure for a water environment and *one* animal fitted by structure for a land environment. [2]
b Explain *two* ways in which the water animal that you have named is fitted by structure to live in its environment. [4]
c Mention the organ of the land animal to which *each* structure named in answer to *b* corresponds. [4]

11 Each of the statements below represents an illustration of some important fact or principle of science. In the blank space after each illustration state the fact or principle involved. [10]

a Houses can be heated by a hot-air system.

....

....

b If one end of a copper wire is held in a flame, the other end soon becomes hot.

....

....

c Plants are able to take in food materials that are dissolved in soil water.

....

....

d Bubbles are often seen on the inside of a glass containing water.

....

....

e A vacuum cleaner is able to remove dust from a rug.

....

....

12 In *each* of the following statements underline the word or expression in parenthesis that best completes the meaning: [10]

a Diphtheria is caused by (flies, mosquitoes, muddy water, bacteria).

b Smallpox is best controlled by (quarantine, vaccination, disinfection, cleanliness).

c A city water supply is purified by (boiling, distillation, aeration, lime).

d Condensation is produced by (chemical action, heating, cooling, oxidation).

e The process of absorption of food in the body depends on (evaporation, condensation, osmosis, respiration).

f Plants secure minerals by (photosynthesis, absorption, transpiration, nitrification).

g Changing starch to sugar is (assimilation, osmosis, digestion, respiration).

h A life process carried on by plants but not by animals is (respiration, assimilation, motion, photosynthesis).

i The addition of cocoa butter to milk for the purpose of increasing the percentage of fat is called (substitution, adulteration, fermentation, condensation).

j The percentage of water vapor in the air is called (evaporation, relative humidity, condensation, saturation).

13 *a* Name *five* important headings commonly used in recording an experiment. [5]

....

....

b Below are given *five* parts of a notebook record of an experiment. In the space at the right classify each part according to one of the headings named in answer to *a*. [5]

(1) Hard water may be softened by the use of borax. ....

(2) One third of a test tube of liquid soap was added to the beaker of hard water. ....

(3) The hard water to which borax was first added formed suds when the soap was put in. ....

(4) How is hard water softened? ....

(5) Borax or other water softener is added to the water before using in order to save soap. ....

14 Complete *each* of the following: [10]

a The atmosphere is composed principally of the elements .... and ....

b Heat in the human body is produced by ....

c Water is formed when oxygen unites with ....

d Burning or combustion is .... oxidation.

e When iron combines with oxygen, ... is formed and .... is released.

f The elements .... and ...., when combined, produce carbon dioxide which may be tested for by the use of ....

15 Give a reason why *each* of the following statements is true or false: [10]

a A steel bridge varies in length throughout the year. ....
....
....

b The rotation of the earth causes day and night. ....
....
....

c A bell vibrating in a vacuum produces sound. ....
....
....

d During respiration, green plants use carbon dioxide and give off oxygen. ....
....
....

e If the barometer reads 30 inches at sea level, it will probably read 30.5 inches at the top of Mount Marcy.
....

Tuesday, June 21, 1932—1.15 to 4.15 p. m., only

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions. Answers to any of the last four questions should be written on the question paper as directed and handed in with the other answer paper.

1 Priestley, one of the discoverers of oxygen, found that under certain conditions some plants replace oxygen in air from which it has been removed by oxidation.

a Give the name of this process. [2]

b Mention *two* conditions necessary for this process. [2]

c Describe with the aid of a drawing an experiment to prove that *one* of the conditions given in answer to *b* is essential to the process named in answer to *a*. [6]

2 *a* Give *two* rules for the care of the eyes. [2]

b What is the function of *each* of the following parts of the eye: iris, lens, retina? [6]

c What relationship does the image formed in the eye bear to the object seen by the eye? [2]

3 People formerly exposed their children to certain diseases so that they would contract them and therefore become immune.

a Name *three* diseases against which we can acquire immunity today without first having the disease. [3]

b Name *one* disease for which we have a serum that aids in the recovery of persons who have contracted the disease. [1]

c Name *three* adaptations of the body that aid in preventing the entrance of disease organisms. [3]

d Mention a contribution of *each* of the following men which is of value in the prevention of disease: Pasteur, Lister, Koch. [3]

4 *a* With the aid of a labeled diagram show a good method of ventilating a room. [4]

b Give *three* main factors that are involved in the proper ventilation of a room and tell why *each* of these factors is necessary. [6]

5 The five observations given below may have been made in connection with experiments during the past year. Write the conclusion of *each* observation. [10]

a Coal, wood and phosphorus are placed on a circle drawn on a square of tin beneath the center of which is placed a Bunsen flame. The phosphorus begins to burn first.

b A thistle tube covered with an egg membrane and containing molasses is placed in a beaker of water. The next morning the molasses has risen in the thistle tube.

c Iron filings or steel wool in a test tube inverted into a beaker of water will rust, and the water will rise one fifth of the way up the tube.

d A laboratory worker noticed that dilute nitric acid turned his fingers and nails a light yellow color, and that when they were touched with ammonium hydroxide, the color changed to an orange-red.

e When the lever of a self-filling fountain pen is released, the ink flows into the rubber reservoir and fills it.

6 Tell whether *each* of the following statements is *true* or *false*, giving a reason for your opinion in each case: [10]

a Humus in the soil aids plant growth.

b Some plants can grow in water because they do not need oxygen.

c A flagpole may cast a shadow similar in shape to itself.

d During the winter, the water in a lake is warmer than the soil of the near-by lake shore.

e A high-pressure area accompanies a storm.

7 *a* Describe an experiment to illustrate that a sounding body vibrates. [5]

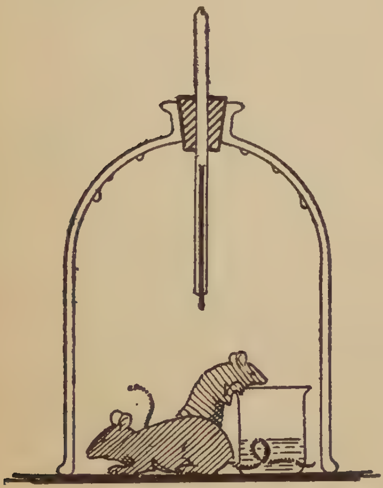
b A bell is vibrating in a distant tower.

(1) Tell through what medium the sound waves reach the human ear. [1]

(2) State the approximate rate of speed of these waves. [2]

(3) Give *two* adaptations of the ear for receiving sound waves. [2]

8 Tell whether *each* of the following statements is *true* or *false*, giving a reason for your opinion in each case:



a Two white rats placed under a bell jar on a desk must be removed within a short time to prevent their death. [2]

b While the rats are under the bell jar, condensed water vapor appears on the inside of the jar. [2]

c Limewater placed inside the bell jar becomes milky in color. [2]

d The temperature reading of a thermometer placed inside the jar remains unchanged. [2]

e If growing plants were used instead of rats, all the reactions referred to in *a*, *b*, *c* and *d* would be different. [2]

9 *a* Compare the effect of a stimulant and a narcotic on the heart action. [4]

b Mention *one* way in which the use of alcohol as a beverage affects *each* of the following: blood clotting, arteries, digestion, resistance to disease. [4]

c Why is smoking by athletes in training forbidden? [2]

10 For each of *five* of the following give *one* reason to show that the statement is true: [10]

a Cooking utensils are often made of metal such as aluminum.

b When food is cooked, water vapor is carried upward.

c As cold water is warmed, bubbles appear on the side of the dish.

d A gas flame deposits soot on the bottom of a pan.

e A liquid in an open vessel boils at a lower temperature in Denver than in New York.

f Energy for cooking is obtained from gas.

11 Explain statements *a, b* and *c,* and answer *d, e* and *f.*

a When an empty flask is inverted into a jar of water and the bottom of the flask is heated, bubbles of air come to the surface of the water. [1]

b When a long glass tube is inserted into a stopper in a flask filled with water and the flask is heated, the water level rises in the tube. [1]

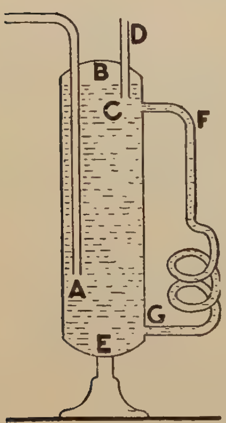
c A metal ball just passes through a ring of the same metal. If the ball is heated, it can not be inserted or withdrawn. [1]

d State how heat is transferred in *each* of the examples in *a, b* and *c.* [3]

e State the principle that summarizes your explanation of the statements *a, b* and *c.* [2]

f Why are telephone wires that are placed in summer allowed to sag? [2]

12 Referring to the accompanying diagram, complete *five* of the following:



a Cold water enters the tank at .... [2]

b The coldest water in the tank is at .... [2]

c Hot water is taken from the tank at .... [2]

d Water goes from .... to the heating coil. [2]

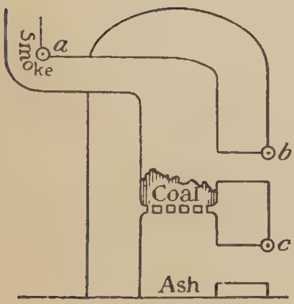
e Heat gets from the flame through the coil to the water by .... [2]

f The outer surface of the tank is sometimes highly polished to prevent .... [2]

g What causes water to flow from the tank when a hot-water faucet is opened? .... [2]

h The heating coil is usually constructed of copper because .... [2]

13 Referring to the accompanying diagram, answer the following:



a Draw a check draft (damper) at *a*, and doors at *b* and *c*, so that coal in the firebox will burn slowly *without* allowing gases to collect in the cellar. [3]

b What is the reason for placing the damper and the doors as you have? [3]

. . . .

c What process occurs in the burning of coal? [1]

. . . .

d What is the ultimate use of this process? [1]

. . . .

e What are *two* waste products of this process? [2]

. . . .

14 In the parenthesis at the right of *each* word or expression in column B write the number of the word or expression in column A that is most closely related to it. [10]

Column A	*Column B*	
1 spontaneous combustion	dew point	( )
2 relative humidity	change of seasons	( )
3 precipitation	kinetic energy	( )
4 westerly winds	insolation	( )
5 intensity of heat rays	borax	( )
6 rotation of the earth	oily rags	( )
7 earth nearer the sun	pressure	( )
8 a moving ball	hygrometer	( )
9 water rising through pipes	eastward	( )
10 revolution of the earth	summer	( )
11 earth farther from the sun		
12 hard water		

15 Insert the word or expression needed to make *each* statement true. [10]

a Gauze is preferred in bandaging a wound because it permits the entrance of .... but prevents the entrance of ....

b Wastes are removed from the body cells by the ....

c The temperature of the body is regulated by the...........

d The function of the villi is to ....

e Oxidation occurs in the .... of the body.

f All exchanges between the blood and the cells take place through the thin walls of the ....

g Most of the calcium of our body is found in the ....

h The .... of the blood carry oxygen.

i .... in the diet of children prevents rickets.

GENERAL SCIENCE

Tuesday, January 24, 1933—1.15 to 4.15 p. m., only

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions. Answers to any of the last six questions should be written on the question paper as directed and handed in with the other answer paper.

1 Explain why *each* of the following statements is true:

a An airplane will not rise indefinitely, no matter how powerful an engine it may possess. [2]

b A balloon will burst if it rises above a certain altitude. [2]

c Papers strewn along the track will "chase" a rapidly moving train. [2]

d A column of mercury in a barometer will not rise above 30 inches at sea level. [2]

e Dust rushes into the dust bag of a vacuum cleaner. [2]

2 Oxygen, heat and an easily combustible substance are necessary to start a fire.

a Why may some substances get warm or even hot without burning? [2]

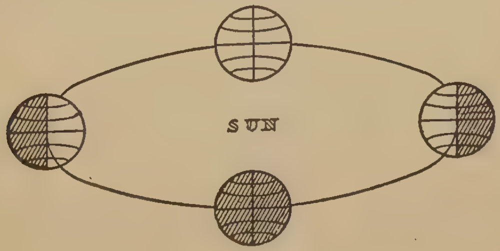
b Why does stepping on a burning match put out the flame? [2]

c Why do most combustible substances turn black if not totally consumed by fire? [2]

d Why are stoves made of iron? [2]

e Why should oily rags never be left about the house? [2]

3 The accompanying diagram was drawn by a student to represent the revolution of the earth around the sun.



a State *one* error that has been made in the diagram. [3]

b Assuming that the earth really revolves about the sun as shown in the diagram, answer the following:

(1) How would the seasons of the temperate zone differ from the present seasons? [3]

(2) What changes would there be in the length of day and night in the frigid zones? [2]

(3) What zone would receive vertical rays from the sun? [2]

4 Explain *five* of the following statements:

a In order to perform its function, lymph must touch not only the walls of the capillaries but also the body cells. [2]

b Water is a product of oxidation. [2]

c The blood contains more carbon dioxide and less oxygen when it leaves the capillaries of the muscles than when it enters. [2]

d There are relatively few bacteria where the soil is dry and sandy. [2]

e Food is fuel. [2]

f Man can not live without oxygen. [2]

5 *a* Give *two* methods used in the control of contagious diseases. [2]

b Name *one* disease that is caused by protozoa. [1]

c Name *one* disease that is caused by bacteria. [1]

d How do the germs of each of these diseases get from one person to another? [2]

e State briefly the health contribution of each of *two* of the following: Pasteur, Lister, Jenner. [4]

6 *a* By what process does the digested food enter the capillaries of the intestines? [1]

b Make a labeled diagram to show the apparatus that was used in an experiment to illustrate this process. [2]

c Give the results obtained in the experiment that you have just illustrated. [3]

d Name *two* structures, other than the intestinal capillaries, that are fitted to carry on this process. [2]

e Name the plant or animal in which *each* of the structures named in answer to *d* is found. [2]

7 *a* State *one* effect of the use of alcohol as a beverage on *each* of the following: digestive juices, arteries, white corpuscles. [6]

b Compare a stimulant with a narcotic with regard to influence on the heart action. [2]

c State *one* reason (other than that implied in answer to *b*) why narcotics should be avoided. [2]

8 *a* Name *two* raw materials needed by green plants for food production. [2]

b State the source from which *each* of the materials named in answer to *a* is obtained. [2]

c Name *two* food materials needed by animals for growth and energy. [2]

d State the source from which *each* of the materials named in answer to *c* is obtained. [2]

e By what process are the raw materials made ready for use by the plant? [2]

9 *a* From the experiments performed during the past year, tell what answers you obtained to *each* of the following questions:

(1) What causes sound? [1]

(2) How may hard water be softened? [1]

(3) What conditions are favorable to the growth of bacteria? [1]

(4) What effect does heat have on gases, liquids and solids? [1]

(5) What is the effect of water on submerged surfaces? [1]

b Give *one* simple application of *each* of the answers to the question in *a*. [5]

10 In *each* group below underline the term that does not belong in the group. [10]

a thermometer barometer hygrometer weather-vane speedometer

b automobile lever pulley wheel and axle screw

c oxygen nitrogen starch hydrogen carbon

d bacteria fungus tree clover protozoa

e carbon dioxide food wood water oxygen

f mushroom yeast mold grass bacteria

g malaria mumps scurvy measles whooping cough

h bacteria grass clover fern geranium

i starch lymph fat sugar protein

j fermentation reproduction nutrition excretion respiration

11 In the parenthesis at the right of each expression in column B write the number of the most closely related term in column A. [10]

Column A	*Column B*	
1 vitamins	enzyme	( )
2 latitude	amount of moisture in the air	( )
3 day and night	rickets	( )
4 cyclone	energy	( )
5 osmosis	rotation of the earth	( )
6 longitude	distance north of the equator	( )
7 work	low-pressure area	( )
8 carbon dioxide	one-celled animals	( )
9 protozoa	transmission of light	( )
10 radiation	prime meridian	( )
11 bacteria		
12 humidity		
13 anticyclone		
14 pepsin		
15 immunity		

12 In the space after each of *five* of the following statements indicate whether it is *true* or *false;* on the lines below each statement selected give a reason why it is true or false: [10]

a Carbon dioxide aids in the process of oxidation.

Reason. . . . .

b Water puts out fire because it is "wet."

Reason. . . . .

c It is hard to move a heavy body.

Reason. . . . .

d A good filter will make sea water fit to drink.

Reason. . . . .

e The waste trap under a sink is useful because it catches dirt.

Reason. . . . .

f Sound travels more rapidly than light.

Reason. . . . .

13 The steps in a laboratory method may be listed as follows:
(1) Recognition of the problem.

(2) Choice of materials.
(3) Use of the materials to produce a natural result.
(4) Observation of the result.
(5) Statement of new facts learned from the experiment (conclusion).
(6) Use of new facts in the solution of other problems.

Read the following statements and after *each* place the number of the step to which it corresponds: [10]

a They tied a stone to one pan of the balance and weighed it. The stone was then allowed to hang in a dish of water and was weighed again. ....

b They agreed that the stone weighs less in water than in air. ....

c A boy thought that he could lift a stone more easily in water than when it was out of water and he decided to experiment to find out the facts. ....

d Balance, dish of water, string, stone. ....

e The stone weighed 15 pounds in air and 13 pounds in water. ....

14 Complete the table below by naming any *four* parts of the eye [2] and giving the use of *each* part [4]. For *each* part of the eye that you have mentioned, name a part of the camera that has the same use [4].

Part of the eye	*Use*	*Corresponding part of camera*
....	....	....
....	....	....
....	....	....
....	....	....

15 Complete *each* statement below by inserting the word or expression needed to make the statement true. [10]

a The correct temperature for a classroom is (4° C., 100° C., 98.6° F., 68° F., 32° F.) ....

b Water boils at ....

c Circulation of air is due to .... currents caused by unequal heating.

d Poorly ventilated rooms are apt to be uncomfortable when they are filled with people because the .... and .... are too high.

e Evaporation of perspiration makes a person feel ....

f .... air can hold more moisture than .... air.

g The temperature of the body is regulated by the .... of the skin.

h The percentage of water vapor in the air is called ....

GENERAL SCIENCE

Tuesday, June 20, 1933—1.15 to 4.15 p. m., only

Answer any 10 questions. Answers should be numbered and lettered to correspond with the questions. Answers to any of the last four questions should be written on the question paper as directed and handed in with the other answer paper.

1 Choose an experiment that has been performed in your class during the past year and under the following headings show what you would place in your notebook: [10]

a Purpose or object of the experiment
b Materials
c Method or procedure
d Observations
e Conclusion drawn

2 All life is dependent on certain factors of the physical environment.
a Name *four* of these factors. [4]
b Show the importance of each of *three* of these factors to living organisms. [6]

3 *a* Describe with the aid of labeled diagrams how you would set up and use apparatus to illustrate the principle by which soil water is taken up by roots. [6]
b Give *two* adaptations of root hairs for absorption. [2]
c What must soil water contain in order to be of the greatest use to plants? [2]

4 *a* Give a reason for not classifying alcohol as a food. [2]
b Give a reason why alcohol may be considered a drug. [2]
c What effect has the use of alcohol as a beverage on the arteries of the body? [2]
d Give the relation of the use of alcohol as a beverage to the operation of an automobile. [2]
e What relation has the use of alcohol as a beverage to the success of an athlete? [2]

5 Explain fully how *each* of the following is related to starch making in leaves of plants: (*a*) chlorophyl, (*b*) carbon dioxide, (*c*) oxygen, (*d*) water, (*e*) sunlight. [10]

6 For each of *five* of the following give *one* reason or evidence to show that the statement is true: [10]
a Light travels more rapidly than sound.

b Water that has been boiled contains little or no air.
c Melting is a physical change.
d Water expands when it is changed to steam.
e Water is given off when a candle burns.
f Some plants do not manufacture their own food.

7 *a* Describe with the aid of fully labeled diagrams an experiment to show that water exerts pressure *or* an experiment to show that convection currents may be produced in water by heat. [6]
b State *two* practical uses in everyday life of the principle illustrated in the experiment described in answer to *a* and in *each* case show how the principle is applied. [4]

8 State the health value of each of *five* of the following modern practices: [10]
a Giving cod-liver oil to children.
b The increased use of green-leaved vegetables in our diet.
c The use of a quart of milk a day for each growing child.
d Building houses so as to admit more sunlight and air.
e Sun bathing in summer.
f The use of devices to introduce moisture into the air of our homes during the winter months.

9 *a* Explain how the circulation of the blood aids in *each* of the following processes: assimilation, respiration, excretion. [6]
b Name *two* agencies that keep the blood flowing through the body. [2]
c State *two* reasons why the clotting of blood is valuable. [2]

10 *a* Make diagrams of the camera and the human eye. [2]
b Label the part of the eye that corresponds to *each* of the following parts of the camera: lens, diaphragm, film (plate or screen). [6]
c Compare the methods by which light rays are focused in the eye and in the camera. [2]

11 A boy breathes through a glass tube into a test tube containing limewater.
a What change takes place in the appearance of the limewater? [2]
b What gas causes this change? [2]
c Of what process in the body is this gas a waste product? [2]
d In what part of the body does this process take place? [2]
e Give the value to an organism of the process named in answer to *c*. [2]

12 Write in the parenthesis at the right of *each* word or phrase in column B the number of the word or phrase in column A most closely related to it. [10]

Column A	*Column B*	
1 oxygen	mixture of gases	( )
2 air pressure	convection currents	( )
3 air	organic matter	( )
4 soil formation	one fifth of the air	( )
5 rain	chemical action	( )
6 carbon dioxide	weathering	( )
7 burning	hygrometer	( )
8 relative humidity	compound	( )
9 wind	precipitation	( )
10 humus	barometer	( )
11 nitrogen		
12 conduction		

13 Write after *each* of the numbers at the right the word or words which, if inserted in the corresponding blank, will make the statement true. [10]

Heat is a form of ..(1).. (1)........
Heat is transferred through iron by ..(2).. (2)........
Protein furnishes ..(3).. for the body. (3)........
We test the presence of carbon dioxide by the use of ..(4).. (4)........
One use of nitrogen in the air is ..(5).. (5)........
The vessels that carry blood to the heart are called ..(6).. (6)........
A long piece of wire ..(7).. when cooling. (7)........
Decay is caused by ..(8).. (8)........
Energy may be either ..(9).. or ..(10).. (9)........
(10)........

14 After *each* illustration below write the letter (*a, b, c, d, e*) of the statement of fact that corresponds to it. [10]

Statements of fact

a Substances have different kindling points.
b Most substances expand when heated.
c The air about us exerts pressure.
d Warm air can hold more moisture than cold air.
e The sun is a source of energy.

Illustrations

1 Food is made by plants with green leaves. ......
2 A hot-air furnace in the basement can warm upper floors. ......

3 Water condenses on spectacles worn by people coming in from outside on a cold day. ......
4 Precipitation frequently occurs when wind blows over the sides and tops of mountains. ......
5 A siphon may be used to take water out of an aquarium. ......
6 One should not strike a match in a gasoline filling station. ......
7 We are able to drink soda water through a straw. ......
8 Steel girders are drawn close together when the rivets cool. ......
9 Paper and fine bits of wood may be used to start a furnace fire. ......
10 As the temperature rises, the reading on a mercury thermometer increases. ......

15 In *each* of the following statements underline the word or expression that best completes the meaning. [10]

a Our bodies are warmed by (evaporation, oxidation, gravitation, digestion, breathing).

b The pressure of air in pounds on every square inch is about (62.4 pounds, 30 ounces, 98.6 pounds, 14.7 pounds, 68 ounces).

c The sun is (a moon, a planet, a comet, a star, a meteor).

d Light travels at the rate of (60 miles an hour, 60 miles a second, 216,000 miles a second, a million miles a second, 186,000 miles a second).

e The atmosphere extends (throughout the universe, to the moon, to a height of only five miles, to a height of about 200 miles, to the sun).

f The approximate diameter of the earth in miles is (4000, 8000, 25,000, 35,000, 100,000).

g The gas necessary for substances to burn in air is (nitrogen, carbon dioxide, steam, helium, oxygen).

h One cause of the change of seasons is (the inclination of the earth's axis, the changing of the earth's distance from the sun, the rotation of the sun, the revolution of the sun, the rotation of the earth).

i Sound travels fastest through (a vacuum, the air, iron, water, wood).

j The number of planets in the solar system is (4, 3, 1, 9, 50, 100).